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THE
ANNUAL REPORT
FOR 1990

INTERNATIONAL ATOMIC ENERGY AGENCY

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LIST OF ABBREVIATIONS

ARCAL	Regional Co-operative Arrangements for the Promotion of Nuclear Science and Technology in Latin America
CANDU	Canadian deuterium–uranium (reactor)
CEC	Commission of the European Communities
CERN	European Organization for Nuclear Research
CMEA	Council for Mutual Economic Assistance
CRP	Co-ordinated research programme
EEC	European Economic Community
EURATOM	European Atomic Energy Community
FAO	Food and Agriculture Organization of the United Nations
HTGR	High temperature gas cooled reactor
ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units and Measurements
ICTP	International Centre for Theoretical Physics
IEA	International Energy Agency (OECD)
IGCP	International Geological Correlation Programme
IIASA	International Institute for Applied Systems Analysis
ILMR	International Laboratory of Marine Radioactivity
ILO	International Labour Office
IMO	International Maritime Organization
INDC	International Nuclear Data Committee
INTOR	International Tokamak Reactor
ISO	International Organization for Standardization
LMFBR	Liquid metal cooled fast breeder reactor
LWR	Light water reactor
NDA	Non-destructive assay
NEA	Nuclear Energy Agency of the OECD
NENS	Division of Nuclear Safety (IAEA)
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
NUSS (programme)	The Agency's programme on nuclear safety standards for nuclear power plants
NWAL	Network of Analytical Laboratories
OAU	Organisation for African Unity
OECD	Organisation for Economic Co-operation and Development
OPANAL	Organismo Proscripción Armas Nucleares América Latina Caribe
PHWR	Pressurized heavy water reactor
PWR	Pressurized water reactor
RCA	Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (INFCIRC/167)
RIFA	Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
RIPC	Division of Physical and Chemical Sciences (IAEA)
SAL	Safeguards Analytical Laboratory
SQ	Significant quantity
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
VIC	Vienna International Centre

WANO	World Association of Nuclear Operators
WASP	Wien Automatic System Planning Package
WHO	World Health Organization
WMO	World Meteorological Organization
WOCA	World outside centrally planned economies area
WWER	Water cooled and moderated reactor (Soviet Union)

1. All sums of money are expressed in United States dollars.

2. The designations employed and the presentation of material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

3. The term ''non-nuclear-weapon State'' is used as in the Final Document of the 1968 Conference of Non-Nuclear-Weapon States (United Nations document A/7277) and in the Treaty on the Non-Proliferation of Nuclear Weapons.

Introduction

The Agency in 1990

The Regular Budget for 1990, at an exchange rate of 11.43 Austrian Schillings to one United States dollar, amounted to $178 653 000, of which $170 135 000 was to be financed from contributions by Member States on the basis of the 1990 scale of assessment, $4 933 000 from income from work for others and $3 584 000 from other miscellaneous income.

The number of Member States of the Agency at the end of 1990 was 112.

At the end of 1990, the number of members of the Secretariat was 2175 — 832 in the Professional and higher categories, 1202 in the General Service category and 141 in the Maintenance and Operatives Service category.

The General Conference reviewed progress made by the Standing Committee on Liability for Nuclear Damage, established by the Board in February 1990, including draft amendments to the Vienna Convention on Civil Liability for Nuclear Damage.

The International Thermonuclear Experimental Reactor (ITER) Conceptual Design Activity, established under the auspices of the Agency, reached a successful conclusion at the end of December 1990. The design agreed among the four Parties is based on the tokamak concept of magnetic confinement. A project plan was developed for future research, development and engineering design work that could be shared among national programmes; a possible schedule and a preliminary cost estimate for construction and operation of the reactor were derived. Discussions began on how and where joint engineering design activities might be carried out.

The International Nuclear Event Scale (INES) was accepted by general consensus for a trial period of operation. By the end of the year, 25 countries had informed the Agency that they were using the scale for rating the safety significance of events and had agreed to report to the Agency within 24 hours information on any events of level 2 or above for worldwide dissemination.

In resolution GC(XXXIV)/RES/529, the General Conference at its session in 1990 endorsed a project for international assistance in assessing the safety of WWER-440/230 plants (i.e. power stations with 440 MW water cooled and moderated reactors of Soviet design) as a complement to national, bilateral and multilateral activities. An Advisory Group met in September to establish the technical and work programme of the project. This includes a review of the conceptual design, safety review missions and studies on matters of generic safety concern.

In connection with an international project, initiated at the request of the Government of the USSR, to assess the health and environmental effects of the Chernobyl accident and evaluate the protective measures taken, fact finding missions visited the affected areas and preliminary reports were prepared under the auspices of an international advisory committee. The report of the committee is being published in 1991.

The following resolution was adopted by the Board of Governors on 24 September 1990:

"The Board of Governors,

> Underlines the obligation of the Director General to take such measures as may be necessary to give effect to Security Council resolution 661 and all Security Council resolutions having relevance to this matter, as well as the guidelines of the sanctions committee established pursuant to Security Council resolution 661, and
>
> Requests the Director General to consult and inform the Board as appropriate."

Important nuclear related matters

At the time of the General Conference session, an agreement on the establishment of the Chernobyl Centre for International Research (scheduled to open in April 1991) was signed by the Governments of the Union of Soviet Socialist Republics, the Ukrainian Soviet Socialist Republic and the Byelorussian Soviet Socialist Republic, on the one hand, and the Agency on the other. The agreement set out the basic conditions for the participation of international teams in the research. Preparations were made for interested parties to meet in Chernobyl in January 1991 to discuss particular projects.

On 28 November 1990 at Foz do Iguaçu, Brazil, the Argentine–Brazilian Declaration on Common Nuclear Policy was signed by the Presidents of the respective countries. At the invitation of the Governments concerned, the Director General attended the signing ceremony and had the opportunity to talk with the two Presidents. This Declaration foresees inter alia the establishment of bilateral full scope safeguards subject to international verification.

Committees and Working Groups of the Board and General Conference

Pursuant to decisions taken by the Board of Governors in June 1989, the Bureau of the Committee on Assurances of Supply (CAS) held further informal consultations with CAS members in 1990. The consultations again centred on principles of international co-operation in the field of nuclear energy and on the supply and demand situation in the world nuclear power market. For the consultations on the latter subject the Secretariat had prepared a background paper on the situation as of March 1990. A report on the consultations was presented to the Board in June 1990, and the Board asked the CAS Bureau to continue with consultations on the basis of two papers, to be prepared by the Agency's Secretariat: (a) an updated paper on the supply and demand situation in the nuclear power market; and (b) a paper designed to facilitate a re-examination of the principles of international co-operation in the field of nuclear energy.

As foreseen, the working group established by the Board to consider various proposals for the financing of safeguards to provide a long term solution reported to the General Conference session in September. It was decided that further meetings would be held in order to move to the next phase of the discussions.

As requested in 1989 by the General Conference, the Board of Governors again re-established "an informal working group open to all Member States in order to continue to examine different proposals on the revision of Article VI of the Statute as a whole". The working group held five meetings during 1990, but there continued to be no consensus on the main substantive issue before it — the possible expansion of the Board's membership. However, in the light of the working group's report the Board (a) affirmed that "all Member States shall be afforded every opportunity to participate fully in the deliberations of the Technical Assistance and Co-operation Committee and the Administrative and Budgetary Committee and that they shall have their views taken into account in the formulation of the Committee's recommendations and reflected in the reports which the Committees submit to the Board" and (b) reaffirmed that "every endeavour should be made for the Committees' recommendations to be achieved by consensus and that this objective would be facilitated by more extensive informal consultations". The working group's report was transmitted by the Board to the General Conference, which, in September 1990, requested the Board to re-establish the group once more with the same mandate. This the Board did immediately after the 1990 session of the General Conference.

General Conference resolutions calling for action by the Director General

In resolution GC(XXXIV)/RES/529, entitled "Measures to strengthen international co-operation in matters relating to nuclear safety and radiological protection", the General Conference urged the Secretariat and the Board of Governors to pursue the strategy outlined in the report contained in document GC(XXXIV)/919, along with other equally important programmes and activities of the Agency in the normal budgetary process, taking into account the overall resource situation. The Director General was requested to pursue further his efforts to promote the effective implementation of the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency. The Conference also requested the Board of Governors and the Director General to report on the implementation of this resolution and of resolution GC(XXXIII)/RES/508 at its thirty-fifth regular session.

In resolution GC(XXXIV)/RES/530, on the Code of Practice on the International Transboundary Movement of Radioactive Waste, the General Conference adopted the Code of Practice. It requested the Director General to take all necessary steps to ensure wide dissemination of the Code of Practice at both the national and international levels, to bring it to the attention of the Secretary-General of the United Nations and the executive heads of United Nations organizations concerned, and to monitor its implementation by Member States and to report to the General Conference as appropriate.

In resolution GC(XXXIV)/RES/531, on the Convention on the Physical Protection of Nuclear Material, the General Conference requested the Director General "to establish and periodically update a comprehensive list of the central authorities and points of contact referred to in Article 5.1 of the Convention, specifying the relevant competences of these national authorities", and to report to the General Conference at its next regular session on the signature and ratification status of the Convention.

In resolution GC(XXXIV)/RES/532, entitled "Nuclear safety guidelines for nuclear-powered vessels", the General Conference requested the Director General "to consult, within the framework of programme priorities, with the International Maritime Organization with a view to ascertaining: the plans of the international maritime community regarding civilian nuclear-powered ships, the need to review the Code of Safety for Nuclear Merchant Ships in the light of existing nuclear safety technology, and whether the Code at present applies to all existing and projected civilian nuclear-powered ships, and if not, the implications of extending the Code to all such ships". The Director General was also requested to report to the Board of Governors on the results of such consultations.

In resolution GC(XXXIV)/RES/533, entitled "Prohibition of all armed attacks against nuclear installations devoted to peaceful purposes whether under construction or in operation", the General Conference requested the Director General to inform the General Conference at its thirty-fifth regular session about developments in this area.

In resolution GC(XXXIV)/RES/540, entitled "Plan for producing potable water economically", the General Conference requested the Director General to contact appropriate United Nations agencies and international and national organizations and institutions with a view to assessing all available information on the future need for potable water relevant to nuclear desalination; to assess in detail — within his competence and with the assistance of international and other organizations concerned and also making use of cost-free experts whenever possible — the costs of potable water production with various sizes of nuclear desalination plant at selected promising sites, with a comparison of the costs of desalination by nuclear and other means; to include nuclear desalination as one of the activities in future programmes of the Agency in the process of preparing the Agency's programme and budget; and to present to the Conference at its thirty-fifth regular session a report on progress in implementing the relevant recommendations contained in the Attachment to document GC(XXXIV)/928.

In resolution GC(XXXIV)/RES/526, entitled "Israeli nuclear capabilities and threat", the General Conference requested the Director General "to deploy further efforts in continuing the consultation with the States concerned in the Middle East area with a view to applying Agency safeguards to all nuclear installations in the area, keeping in mind the relevant recommendations contained in paragraph 75 of the report attached to document GC(XXXIII)/887, as well as various proposals and opinions referred to in the governments' replies contained in document GC(XXXIV)/926 and the situation in the area of the Middle East, and to report on the matter to the Board of Governors and to the General Conference at its thirty-fifth regular session." The Director General was also requested to inform the Secretary-General of the United Nations of this resolution.

In resolution GC(XXXIV)/RES/545, on South Africa's nuclear capabilities, the General Conference resolved "to consider and take a decision on the recommendation of the Board of Governors contained in its report GC(XXXI)/807 to suspend South Africa from the exercise of the privileges and rights of membership of the Agency in accordance with Article XIX.B of the Statute at the Conference's thirty-fifth regular session." The Director General was requested "to continue to take all possible measures to ensure the full implementation of resolution GC(XXX)/RES/468 and to report to the General Conference at its thirty-fifth regular session in this regard". The Director General was also requested to bring this resolution to the attention of the Secretary-General of the United Nations.

In addition, resolutions were adopted on the examination of delegates' credentials (GC(XXXIV)/RES/527); the Agency's accounts for 1989 (GC(XXXIV)/RES/528); the regular budget appropriations for 1991 (GC(XXXIV)/RES/534); the technical assistance and co-operation fund allocation for 1991 (GC(XXXIV)/RES/535); the working capital fund in 1991 (GC(XXXIV)/RES/536); the scale of assessment of Members' contributions for 1991 (GC(XXXIV)/RES/537); the financing of safeguards (GC(XXXIV)/RES/538); the financing of technical assistance (GC(XXXIV)/RES/539); the staffing of the Agency's Secretariat (GC(XXXIV)/RES/541); the amendment of Article VI.A.2 of the Statute (GC(XXXIV)/RES/542); the revision of Article VI of the Statute as a whole (GC(XXXIV)/RES/543); and rule and policy on the appointment of the Director General (GC(XXXIV)/RES/544).

Matters of special interest to the Agency discussed by the General Assembly of the United Nations

Several matters of interest to the Agency were discussed at the forty-fifth session of the General Assembly. In the debate that followed the presentation of the Agency's annual report for 1989, delegates indicated their broad support for the Agency, its safeguards system, its technical co-operation programme and its work in the field of nuclear safety. In its resolution on the report, the General Assembly affirmed "its confidence in the role of the Agency in the application of nuclear energy for peaceful purposes" and urged all States to co-operate in carrying out the work of the Agency.

The General Assembly adopted the following resolutions which are of direct interest to the Agency: the establishment of a nuclear-weapon-free zone in the region of the Middle East (A/RES/45/52); the implementation of the Declaration [on the Denuclearization of Africa] (A/RES/45/56A); the nuclear capability of South Africa (A/RES/45/56B); the prohibition of attacks on nuclear facilities (A/RES/45/58J); the prohibition of the dumping of radioactive wastes (A/RES/45/58K); Israeli nuclear armament (A/RES/45/63); the effects of atomic radiation (A/RES/45/71); the international co-operation to address and mitigate the consequences of the accident at the Chernobyl nuclear power plant (A/RES/45/190); and a United Nations Conference on environment and development (A/RES/45/211).

Nuclear power

Nuclear power planning and implementation

Regional/national workshops

Two regional workshops (of one week duration) were organized as a means of promoting the exchange of experience in the use of Agency methodologies for energy, electricity and nuclear power planning, with emphasis on the Agency's WASP and MAED planning tools. The first was organized under RCA and was held in the Republic of Korea. The second was organized for countries in the Americas, and was held in Costa Rica.

A national workshop was held in Seoul with the aim of deploying an integrated energy planning and environmental impact assessment capability in the Republic of Korea. This project attempted to incorporate explicitly environmental impacts into energy planning, with emphasis on the Agency's Energy and Power Evaluation Program (ENPEP).

Economic comparisons

The comparative electricity generation costs of nuclear and conventional power plants in ten Member States were surveyed and analysed, and a report in the IAEA-TECDOC series was published.

Support for developing Member States

In connection with the programme to provide support for developing Member States, especially for project feasibility studies, infrastructure development planning, manpower planning and project management:

- Support was provided to Malaysia in connection with the transfer of the microcomputer based ENPEP.
- Two nuclear power planning advisory team (NUPAT) missions were carried out, one to Morocco and the other to Malaysia. Recommendations were made on governmental action plans and on further steps needed in preparation for the eventual introduction of nuclear power.
- A feasibility study for the implementation of small and medium power reactors (SMPRs) in the long term power programme of Egypt was initiated. The study will include an evaluation of the technical, economic and financial aspects of SMPRs and a comparison with coal power plants, and will be completed in 1991.

In connection with the Agency's programme to provide support for existing nuclear power projects in developing Member States:

- Support continued to be provided to the Islamic Republic of Iran in the review of the Bushehr nuclear power project.
- Support was provided to Romania in the review of the Cernavoda nuclear power project and the identification of various actions to be initiated by the project authorities.

Assistance to Member States in the field of quality assurance continued to be provided through 11 technical co-operation projects. Support was given in the form of training courses for the development of qualified manpower, fellowships, expert services and equipment for non-destructive examination (NDE)

Support for developing Member States (cont.)

and in-service inspection techniques. Projects under way involved the following countries: Bulgaria, Czechoslovakia, Egypt, Hungary, Indonesia, the Republic of Korea, Pakistan, Poland and Yugoslavia.

Contracting and financing

A topical seminar on the financing of nuclear power projects in developing countries was organized in Indonesia to examine the problems and constraints of financing and to explore possible means of alleviating them. The presentations and discussions focused on nuclear generation costs, the financing constraints facing nuclear power projects and new approaches for large energy project financing.

Progress continued to be made on the preparation of a reference book on financing arrangements for nuclear power projects in developing countries.

Senior Expert Symposium on Electricity and the Environment

The Joint Steering Committee for the Senior Expert Symposium on Electricity and the Environment (13-17 May 1991, in Helsinki) met twice. Each of the four expert groups also met twice and completed preliminary drafts of the respective key issue papers: energy and electricity supply and demand; energy sources and technologies for electricity generation; comparative environmental and health impacts of different energy sources for electricity generation; and incorporation of environmental and health factors into policy, planning and decision making for the electricity sector. The symposium, organized by the Agency jointly with the CEC, CMEA, IIASA, OECD/IEA, OECD/NEA, UNECE, UNEP, WHO, WMO and the World Bank, is expected to provide valuable inputs to electricity supply planning and decision making, and to the United Nations Conference on the Environment and Development, to be held in 1992.

Comparative assessments

Work continued on comparative assessments of nuclear power and other energy sources, in particular with regard to the potential to avoid greenhouse gas emissions and global warming. This work includes:

- Active participation in the Intergovernmental Panel on Climate Change (IPCC); the Conference on Action for a Common Future, held in Bergen in May 1990; the second World Climate Conference; and other international forums on environmental issues.
- Co-operation with the World Bank and national development agencies in the initial phase of a project to prepare an environmental data manual. Agreement on the structure and content of this document has been achieved, with publication of a basic version of the manual planned for 1991.
- Preparation of papers on the potential for CO_2 avoidance through the use of nuclear power.
- Preparation of a report on the technical and economic potential for renewable sources of energy to contribute to electricity supplies (planned for publication in 1991).

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on electric system expansion planning (WASP and VALORAGUA)	USA	25	9 weeks
National seminar for decision makers on the bidding process for nuclear power plants	Czechoslovakia	15	1 week
Regional course on nuclear power project planning and implementation (RCA)	Rep. of Korea	16	3 weeks
Regional seminar for decision makers on nuclear power in Latin America and the Caribbean	Mexico	40	1 week
Topical seminar on financing of nuclear power projects in developing countries	Indonesia	109	3 days
Workshop on electricity demand and supply planning for North American and Latin American countries (WASP and MAED)	Costa Rica	3	1 week
Workshop on energy, electricity and nuclear power planning (WASP and MAED) (RCA)	Rep. of Korea	15	1 week
Workshop on integrated energy planning and environmental impacts assessment (ENPEP)	Rep. of Korea	15	2 weeks

Publications

Series and No.	Title
IAEA Yearbook 1990	Nuclear power, nuclear fuel cycle and waste management: status and trends 1990
IAEA-TECDOC-569	Projected costs of nuclear and conventional base load electricity generation in some IAEA Member States
Reference Data Series No. 1	Energy, electricity and nuclear power estimates for the period up to 2005

Nuclear power plant performance

PRIS

The Agency's Power Reactor Information System (PRIS) continued as a main tool for the statistical analysis of nuclear power plant performance. In 1990, PRIS was kept operating on-line free of charge. Currently, 50 users in 23 Member States and 2 international organizations have on-line access to PRIS.

In parallel with the on-line access system, the Agency completed preparations for offering a new service — micro-PRIS — to Member States. This is a personal computer (PC) version of PRIS data available on diskette in a form readily accessible by standard, commercially available PC packages. The product is a result of a project which started in the middle of 1989 on the basis of a research contract between the Agency and the Nuclear Information Centre of the Czechoslovak Atomic Energy Commission.

An Advisory Group meeting was held in Vienna in September to obtain advice on possible improvements to PRIS. The group, comprising 11 experts from 9 Member States and, for the first time, WANO, made several recommendations, specifically the need to restructure the mainframe version of PRIS in order to include two more international performance indicators (unit capability factor and unplanned capability loss factor), expansion of the outage plant coding system and information on reactor characteristics.

Availability

Co-operation with the World Energy Conference (WEC) and the International Union of Producers and Distributors of Electrical Energy (UNIPEDE) continued in studies on the availability of electrical power plants. The world overall energy availability of nuclear power plants in 1989 (the last year for which complete data are available) was 69.6% (72.1% in 1988). The main cause for this drop in energy availability was the energy loss owing to planned full outages (an increase from 826 GW·h per unit in 1988 to 1091 in 1989). However, the number of unplanned full outages per unit decreased from 3.94 in 1988 to 3.12 in 1989, and the energy loss per unit during unplanned full outages decreased from 426 GW·h in 1988 to 402 in 1989.

Good practices for outage management in nuclear power plants

A technical document on outage management in nuclear power plants was prepared and approved by an Advisory Group meeting for publication early in 1991. The document was developed to promote effective outage management and, ultimately, more efficient worldwide nuclear power plant performance. The document emphasizes actual good practices in the key aspects of outage management. Preparations were made for a seminar on efficient outage planning and management in nuclear power plants, to be held in April 1991.

Man-machine interface studies

An international symposium on balancing automation and human action in nuclear power plants, organized in co-operation with the OECD/NEA, was held in Munich, Germany. The meeting considered the present situation relating to the balance between automation and human control, focused on the reasons which have led to the various solutions adopted, clarified the decision making process and provided a basis for the development of objective criteria. An important keynote paper presented at the symposium reviewed the work of the International Working Group on Instrumentation and Control, set up by the Agency in 1989, which proposed a general methodology for arriving at the correct balance between automation and human action.

Instrumentation and control

A specialists meeting on communication and data transfer in nuclear power plants was held in Lyon, France. The purpose of the meeting was to provide an opportunity to: exchange experience gained in design, manufacture, installation and qualification on new control systems in both safety and non-safety nuclear power plant applications; consider the advantages and disadvantages of these control systems; and share the practical experience gained in their operation. The possible areas for international co-operation, including organization of a CRP on the subject, were discussed.

A specialists meeting on analysis and experience in instrumentation and control, with particular emphasis on the application of reliability calculation methods and their use as decision tools to select instrumentation and control for nuclear power plants, was held in Arnhem in co-operation with the Netherlands Nuclear Safety Department. Particular attention was devoted to the problems of probabilistic reliability analysis, expert systems for advanced process analysis and control, software tool development and development trends.

Training simulators

On the basis of recommendations by an Advisory Group on the use of simulators for training and maintaining competence, a technical document was prepared containing information on different types of training simulators, with emphasis on the development of criteria for establishing a training centre.

Nuclear power plant ageing and life extension

The mandate of the International Working Group on Reliability of Reactor Pressure Components, which had been carrying out ageing related studies over many years, was extended to deal with all aspects of reliable plant life management. The group now has the name of Nuclear Power Plant Life Management (IWG-NPPLM). The following meetings were conducted by the Agency under this programme:

- Specialists meeting in Moscow in May on subcritical crack growth;
- Specialists meeting in Balatonfüred, Hungary, in September, on radiation embrittlement of nuclear reactor pressure vessel steels;
- Specialists meeting in Stockholm in October on nuclear power plant lifetime assurance;
- A CRP meeting which reviewed the status of the programme mentioned above and outlined the activities in the final stage;
- A consultants meeting on the updating of Technical Reports Series No. 163, Neutron Irradiation Embrittlement of Reactor Pressure Vessel Steels. The updated version will be completed in the first half of 1991.

Grading of quality assurance requirements

A manual providing guidance in determining and adjusting graded quality assurance (QA) requirements for items and services in a nuclear power plant, in compliance with the requirements of the corresponding IAEA NUSS Codes and Safety Guides, was completed. This manual provides users (owners, designers, purchasers, manufacturers, constructors, operators and regulators) with a practical method of grading QA requirements and examples which are currently in use in Member States. It will be published in the Technical Reports Series.

Effectiveness of quality management for nuclear power plant operation

A report providing guidelines to superintendents of operating nuclear power plants for carrying out self-assessments of the effectiveness of quality management was completed. The effectiveness is assessed with respect to the overall performance, including the achievement of safety, reliability and economic

Effectiveness of quality management for nuclear power plant operation (cont.)

objectives. The diversity of approaches and interpretations among Member States on how to assess effectiveness was taken into account. The proposed assessment method is based on the experience reported to date. The report will be published in the IAEA-TECDOC Series for trial use.

Quality assurance integrated training packages

A draft report which provides guidance for establishing training programmes covering QA principles and practices was prepared and reviewed by an Advisory Group. The report proposes training packages which can be suitably adjusted for various management levels and adapted to national variables and needs in the field of QA and is based mainly on experience and material collected from approximately 50 interregional, regional and national training courses, seminars and workshops on QA organized by the Agency in 20 Member States. It is planned for publication in 1991.

Safety Guide on QA for nuclear power plant siting

Work was initiated on a new Safety Guide on QA. The publication will describe acceptable methods of implementing QA requirements, as established in the relevant NUSS Codes, for the siting stage of nuclear power plants. The first draft of the Safety Guide was prepared and it will be reviewed by an Advisory Group in 1991.

Revision of QA Safety Guides

Work was initiated to revise all ten existing NUSS Safety Guides on QA. The Guides will be updated to reflect current concerns and practices and to ensure consistency between the Guides and the current Code on Quality Assurance, which was revised in 1988. Revision of the entire series of Guides will provide the opportunity to improve the present structure, to make the documents more user friendly, to streamline the wording and to reduce the amount of repetition.

Regional seminar for Europe and the Middle East on quality management

The first regional seminar for Europe and the Middle East on quality management for nuclear power projects was hosted by Czechoslovakia in Prague in November. The aim of the seminar was to inform and instruct management personnel from nuclear power projects, national regulatory organizations and the nuclear industry on quality management principles and recommended practices. The seminar provided a forum to review and discuss regional problems in the effective implementation of quality requirements and the possible solutions to them.

Quality standards for operating personnel

Work was completed on compiling information on procedures used for the authorization and licensing of nuclear power plant operations personnel and on the accreditation of training programmes. An IAEA-TECDOC will be published in 1991.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional seminar for Europe and the Middle East on quality management for nuclear power projects	Czechoslovakia	106	1 week
Interregional course on project management strengthening with emphasis on quality assurance	India	25	6 weeks
Interregional course on qualification of nuclear power plant operations personnel	Germany	25	5 weeks
National course on quality assurance auditing for nuclear power plants	Indonesia	36	2 weeks
National course on quality assurance for computer software	Rep. of Korea	28	2 weeks
National course on quality assurance for mechanical equipment	Pakistan	37	3 weeks
National course on quality assurance in design, procurement and manufacture of nuclear power plants	Indonesia	30	2 weeks
Regional workshop on NDT, audits and erosion-corrosion of reactor pressure vessels and piping of WWER type reactors	Spain	9	2 weeks
Workshop on electric grid and plant interaction	China	35	2 weeks
Workshop on in-service inspection	Yugoslavia	6	2 weeks

Publications

Series and No.	Title
Technical Reports Series No. 315	Quality management for nuclear power plant operation
Technical Reports Series No. 317	Implementation of quality assurance corrective actions
IAEA-TECDOC-546	Common modelling approaches for training simulators for nuclear power plants
IAEA-TECDOC-565	Control rooms and man-machine interface in nuclear power plants
IWG-NPPCI-90/1	Nuclear power plant control and instrumentation 1989
IWG-RRPC-88-1	Corrosion and erosion aspects in pressure boundary components of light water reactors
IWG-RRPC-88-2	Ninth regular meeting of the International Working Group on Reliability of Reactor Pressure Components
Reference Data Series No. 2	Nuclear power reactors in the world
NUREG/CP-0112; ANL 90/22, Vol. 2	Subcritical crack growth
	Residual stresses in structural materials and components of nuclear power plants
	Operating experience with nuclear power stations in Member States in 1989

Nuclear power system technologies

IWGFR

At its 23rd annual meeting, the International Working Group on Fast Reactors (IWGFR) reviewed the status and current trends in national LMFBR development programmes. The conceptual design of a 1500 MW(e) unit by the European Fast Reactor Utilities Group is in progress. On completion of this stage the concept validation stage will follow to analyse advanced options. In the USA, substantial progress has been made in the advanced design development of PRISM. In the USSR, it was decided to extend the BN-1600 design approach to find additional solutions which provide greater safety and better economics. Construction work at the MONJU plant in Japan is progressing according to schedule, with more than 80% already completed. In addition to the members of the Group (Member States directly involved in fast reactor development), the meeting was attended by observers representing China and the joint fast reactor project of Argentina and Brazil.

Reliable operation of LMFBR steam generators

In the framework of the technical information exchange activities of the IWGFR, two specialists meetings on LMFBR steam generator failure and steam generator sodium–water acoustic leak detection were held. The wide range of laboratory tests and nuclear power plant steam generator operational experience was discussed. The main conclusions of these meetings were the following:

- Experience has shown that good hydrogen detection with accurate signal analysis is essential to allow rapid steam generator shutdown when leaks occur.
- Despite the various leaks, nuclear power plant operators have confidence that sodium–water reactions do not present safety problems which cannot be resolved with current technology.
- Acoustic/ultrasonic monitoring of water into sodium leaks is now considered by all countries to be a major area in commercial fast reactor steam generator protection.
- All participating countries have started work in this area. Future work should aim at a more precise definition of the acceptable limits, taking into account the particular requirements of actual plant design.

IWGGCR

At its ninth meeting, the International Working Group on Gas Cooled Reactors (IWGGCR) reviewed the status of national GCR programmes and made recommendations on topics for future Agency activities. Particular highlights in this field are the further progress of the Japanese High Temperature Engineering Test Reactor (HTTR) project, which has reached the construction permit stage, the progress in the licensing procedure for the conceptual design of the modular HTR (pebble bed) in Germany and the high temperature gas cooled reactor (HTGR) (prismatic fuel) in the USA. The project for a test module in Dimitrovgrad, USSR, has been delayed, but not abandoned.

HTR fuel

As part of technical information exchange and international co-operation, a specialists meeting was held on the behaviour of gas cooled reactor fuel under accident conditions. The status of the work and the results achieved so far were presented and discussed at the meeting. Recommendations were also made for future priorities in the R&D still required and the sharing of these activities.

HTGR physics

As recommended by the IWGGCR, a CRP on the validation of safety related physics calculations for low enriched HTGRs was initiated. Within this programme results from the experimental critical facilities PROTEUS at the Paul Scherrer Institute, in Switzerland, and VHTRC, at the Japan Atomic Energy Research Institute (JAERI), play a key role in the validation of physics codes.

IWGATWR

At its third meeting, the International Working Group on Advanced Technologies for Water Cooled Reactors (IWGATWR) reviewed and discussed the status and progress made since 1988 in advanced technology development and design trends for existing and new water reactor designs, along with related national technology development programmes. A progress report on the development programmes in Member States was published as an IWG report.

Cost reduction of water cooled power plants

The interest in methods and technologies to reduce the costs of water cooled reactor power plants is considerable, not only in industrialized countries with operating power plants, but also in developing countries which have power plants under construction. At a specialists meeting held in Helsinki, Finland, it was suggested that the preparation of an Agency document on cost reduction guidelines would be of value to Member States.

Nuclear applications for steam and hot water supply

A report was prepared describing the experience of those Member States which employ or plan to use nuclear power plants or specialized nuclear heat plants for utilizing heat energy in the form of steam or hot water for industrial or domestic consumers. It is hoped that this report will serve as a source of useful information for future case studies which can be undertaken with the Agency's assistance by Member States.

Thermophysical properties

A CRP on the establishment of a thermophysical properties database for light and heavy water reactor materials was expanded to achieve wider Member State participation. The programme aims at the establishment of an evaluated and standardized database and the development and generation of reliable new data (thermal conductivity, thermal diffusivity, specific capacity, enthalpy, heat of melting, coefficient of thermal expansion, emittance and density). Participants in the CRP are China, Czechoslovakia, Germany, India and Yugoslavia.

Safety related terms

An Agency draft working paper on the description of safety related terms for advanced nuclear plants was reviewed, discussed and prepared for publication. The purpose of the paper is to present a better technical description of these terms and thereby achieve a greater understanding and consensus on their meaning and proper use.

Reactor physics

During a Technical Committee meeting held in Nuremberg, Germany, worldwide studies for the implementation of high converter reactors were discussed. For physical and thermohydraulic reasons, the original design which featured a very tight lattice of fuel pins for such reactors was widened relative to those of current PWRs. In addition, the fuel element geometry was changed from a square to a hexagonal lattice.

Major efforts in the development and improvement of new codes, including new methods and procedures, have been made by industrial countries to make better predictions of reactor physics parameters. The new methods were discussed at a specialists meeting on advanced calculational methods for power reactors, held

Reactor physics (cont.)

in Cadarache, France, where it was concluded that these methods were capable of calculating advanced fuels and complex geometries of next generation reactors with a high level of accuracy. The importance of supercomputing and online monitoring was also acknowledged.

Nuclear desalination

In accordance with the 1989 General Conference Resolution Plan for the Production of Low Cost Potable Water (GC(XXXIII)/RES/515), a status report on the use of nuclear reactors for seawater desalination was prepared and published as IAEA-TECDOC-574. A total of 16 experts from 9 countries (Argentina, Canada, Egypt, Germany, Israel, Japan, the Libyan Arab Jamahiriya, the USA and the USSR) participated in the drafting and review of this document. It was recognized that the Middle East and the southern part of the Mediterranean Sea are two regions of the world facing a severe shortage of potable water. A rough estimate by the experts indicated that by the year 2000 there will be a shortage of about 12 million m^3/day in these areas. The expected increasing shortage of potable water in the near term in many parts of the world makes it necessary to consider more advanced, but more economic, production schemes than are available today.

The report presented the experience in the USSR since 1973 of nuclear desalination at Shevchenko and some recent feasibility studies for selected areas, such as the Southern California Desalination Study (USA), the Super-Safe, Small and Simple Liquid Metal Cooled Reactor (Japan) and the HTR Module for Seawater Desalination (Germany). On the basis of these studies, the USSR experience and currently available technologies, it was concluded that nuclear desalination is technically feasible, but the economic feasibility must be confirmed on a site specific basis. The target specific cost of the potable water produced should be less than \$1/m^3. In addition to the financial obstacle, there are other institutional barriers to nuclear desalination, such as regulatory issues and public acceptance.

Desired characteristics for advanced reactors

A draft working paper containing a set of desirable characteristics for advanced reactors with quantified, internationally acceptable goals, where possible, was prepared and reviewed at a number of consultants meetings and during a Technical Committee meeting held in China. The characteristics and associated development goals, as specified by potential future users of advanced reactor plants, are independent of a specific reactor concept and may serve as a guide for vendors in designing advanced reactors.

Fusion research and engineering

In close co-operation with the International Thermonuclear Experimental Reactor (ITER) project, a CRP on the lifetime behaviour of the first wall of fusion machines was initiated. As a first step, the execution of benchmark calculations on the lifetime of the first wall was agreed upon by all participants using a defined set of parameters. A comparison of the results is planned as the next step.

ITER

Support has continued to be given to the ITER project through the ITER Secretariat and IAEA-ITER Liaison Officers. Three ITER Council meetings were organized in Vienna and one in Washington, D.C. The ITER conceptual design activities have led to a single design for a facility that could achieve the objectives established for the project. The Conceptual Design Phase was completed in 1990. It is expected that an Engineering Design Phase will begin early in 1991.

Plasma physics conference

The 13th Conference on Plasma Physics and Controlled Nuclear Fusion Research was attended by 533 experts and 110 observers from 30 countries and 2 international organizations; over two hundred papers were presented, reflecting the fact that steady and significant progress had been made in both magnetic and inertial fusion research. In particular, results were reported on: tokamak experiments; inertial confinement; non-tokamak confinement systems; magnetic confinement theory and modelling; plasma heating and current drive; ITER; technology and reactor concepts; and the economic, safety and environmental aspects of fusion.

Special plasma and fusion topics

Technical Committee meetings were held on tokamak transport, time resolved plasma diagnostics and research using small tokamaks to review the state of the art in these fields. The proceedings of the last meeting will be published as an IAEA-TECDOC.

***Nuclear Fusion* journal**

Twelve issues of *Nuclear Fusion* were published. Of special importance was the 30 year anniversary issue, comprising a complete status report on controlled thermonuclear fusion prepared by the International Fusion Research Council.

Cumulative index

The input of all the data for a 30 year cumulative subject and author index for *Nuclear Fusion* was completed. The index will be published as a special issue early in 1991.

'World Survey'

The sixth edition of the special supplement, World Survey of Activities in Controlled Fusion Research, was essentially completed for publication.

Supplement on atomic and molecular data for fusion

Articles for a supplement on atomic and plasma material interaction data for fusion were compiled and processed. Publication is foreseen for the first quarter of 1991.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Development of advanced diagnostics for edge plasma studies	1990	7
1988	In-core fuel management code package validation for LWRs	1991	8
1988	Safe core management with burnable absorbers in WWERs	1992	9
1989	Acoustic signal processing for the detection of boiling or sodium-water reactions in LMFBRs	1992	7
1989	Validation of physics calculations for low enriched HTGRs	1992	6
1989	Lifetime behaviour of the first wall of fusion machines	1992	7
1989	Benchmark for in-core fuel management programs for PHWRs	1992	7
1990	Establishment of a thermophysical properties database for light and heavy water reactor materials*	1993	5

* Scope redefined.

CRPs established in the current year

Subject	No. of years	Participating institutions
Intercomparison of LMFBR seismic analysis codes	3	7

Publications

Series and No.	Title
Technical Reports Series No. 312	Gas cooled reactor design and safety
ITER Documentation Series No. 6	ITER Council proceedings: April 1988–August 1989
ITER Documentation Series No. 7	ITER conceptual design: interim report
ITER Documentation Series No. 8	Initial report of the ITER Council's Ways and Means Working Party
ITER Documentation Series No. 9	ITER activities status report: December 1989
ITER Documentation Series No. 10	ITER physics design guidelines: 1989
ITER Documentation Series No. 11	Report on the ITER Council's Ways and Means Working Party
ITER Documentation Series No. 12	ITER activities status report: April 1990
ITER Documentation Series No. 13	ITER Council proceedings: September 1989–May 1990
ITER Documentation Series No. 14	Preliminary ITER cost and schedule estimates
	Status report on controlled thermonuclear fusion
IWGATWR/3	Passive safety features in current and future water cooled reactors
IWGFR-67	Specialists meeting on sodium fires
IWGFR-69	Methods for reactor physics calculations for control rods in fast reactors
IWGFR-73	Status of national programmes on fast breeder reactors
IWGFR-75	Verification and validation of LMFBR static core mechanics codes. Part I
IWGFR-76	Verification and validation of LMFBR static core mechanics codes. Part II
IWGGCR-22	Seismic behaviour of gas cooled reactor components
IWGGCR-23	Design codes for gas cooled reactor components
IAEA-TECDOC-536	Impurity control in toroidal devices
IAEA-TECDOC-541	Role of advanced nuclear power technologies in developing countries: criteria and design requirements
IAEA-TECDOC-558	Stellarator physics
IAEA-TECDOC-567	In-core fuel management practices
IAEA-TECDOC-574	Use of nuclear reactors for seawater desalination

Nuclear fuel cycle

Environment and the nuclear fuel cycle

An Advisory Group meeting was held at Agency Headquarters on the environmental effects of nuclear fuel cycle facilities and public attitudes towards them. It was recognized that communications programmes and initiatives implemented by power plant managers could be effective in improving public understanding and acceptance of nuclear energy. A report on the subject is being prepared for publication.

Planning of nuclear fuel cycle facilities in developing countries

An interregional training course on the planning of nuclear fuel cycle facilities in developing countries was held in Bariloche, Argentina. The course material covered various aspects of the nuclear fuel cycle and nuclear power plants for electricity generation. Thirty-seven participants from 22 countries attended the course.

Resources of nuclear raw materials

Supply–demand analysis

As part of the programme to maintain and improve the quality and coverage of estimates of world nuclear fuel resources, supply and demand, an analysis was made of the status of the uranium industry and the likely future developments. Uranium production in WOCA in 1990 is expected to show a further decrease by about 5000 t, to about 30 000 t U, in response to current market conditions. Seven countries produce nearly 95% of the total and the 'rest of WOCA', with the remaining 5% of the total production, includes about ten countries, of which Gabon is the most important producer. The reactor related uranium demand in 1990 is estimated at 43 800 t U. The resulting underproduction comes to approximately 13 800 t U, covered by imports from China and the USSR, as well as by material in stocks and inventories held in WOCA. By the year 2005, the supply based on expected production from producer countries in WOCA is projected to level off, while uranium requirements will grow to nearly 53 000 t. The continuing deficit in production may increase to over 25 000 t U in 2005, reaching for the period 1990–2005 a cumulative total of over 275 000 t U, or over 36% of the cumulative requirements. This deficit can be filled by surplus stocks, which in WOCA are estimated at about 60 000 t U. Additional supplies may come from non-WOCA material.

'Red Book'

A new edition of the 'Red Book', a joint report of the Agency and the OECD/NEA, was published. Relatively complete statistics and analyses on uranium resources, exploration, and supply and demand projections up to 2005 and 2030 for WOCA are included in this report. Also, data are included from Member States which did not provide any in the past. If this development continues, the report will become a source of *world* uranium data, providing Member States with wider scope and more authoritative information.

World atlas of uranium deposits

Preparation of a comprehensive world map of uranium deposits was initiated. The project is expected to be completed by the end of 1992. In addition, the manuscript of an instruction manual on the estimation and economic evaluation of undiscovered uranium resources was prepared and submitted for publication.

Radioelement map of the world

As a continuation of the effort to promote wider use of uranium exploration data and technology in geological research and the assessment of other mineral resources and, more importantly, as baseline information for environmental study and monitoring, a Technical Committee meeting (workshop) on geochemical and radioelement maps of the world was organized in Prague, Czechoslovakia. The meeting was held in conjunction with the UNESCO-IUGS International Geological Correlation Project. At the meeting, it was recommended that the Agency continues to act as the co-ordinating body for the radiometric methods of the project. To date, the Agency has an inventory on the status and extent of past surveys in about fifty countries.

Uranium provinces in Asia

Asia is among the few regions of the world with a projected strong growth in nuclear power generation and related uranium requirements. In this connection, a Technical Committee meeting on uranium provinces in Asia and the Pacific was held in Beijing, China. Of importance was a report on uranium provinces of China prepared by Chinese delegates. One of the recommendations made at the meeting was for the formation of a working group to prepare a uranium metallogenic map of Asia.

Uranium analytical techniques

A report on analytical techniques in uranium exploration and ore processing was submitted for publication. The report seeks to provide users with a selection of the most important standard methods and procedures for the determination of uranium and associated elements.

Technical co-operation

Twenty-seven technical co-operation projects on various aspects of uranium exploration and development were supported.

Publications

Series and No.	Title
Technical Reports Series No. 309	Construction and use of calibration facilities for radiometric field equipment
IAEA-TECDOC-566	The use of gamma ray data to define the natural radiation environment

Processing of nuclear and reactor materials

Monograph on uranium extraction technology

Preparation of a monograph on uranium extraction technology is in the final phase. The manuscript is expected to be completed for publication during the first half of 1991. This report represents an update of the previous joint Agency–OECD/NEA publication on the subject issued in 1982.

A guidebook on the development of projects for uranium mining and ore processing was submitted for publication.

Safe UF_6 production and transport

A draft report on the safe production, transportation, handling and storage of UF_6 was revised and is now ready to be submitted for publication.

Two technical co-operation projects on uranium extraction from phosphoric acid were supported.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on the planning of nuclear fuel cycle activities in developing countries	Argentina	37	3 weeks

Publications

Series and No.	Title
Technical Reports Series No. 313	Manual on laboratory testing for uranium ore processing
Technical Reports Series No. 314	Guidebook on design, construction and operation of pilot plants for uranium ore processing
IAEA-TECDOC-555	Some economic aspects of low enriched uranium production

Reactor fuel design, fabrication and performance

IWGFPT

Activities in the area of water reactor fuel technology continued according to the guidance established by the International Working Group on Water Reactor Fuel Performance and Technology (IWGFPT), which consists of participants from 26 Member States and 4 international organizations. Three IWGFPT reports were issued.

Post-irradiation examination

A Technical Committee meeting on post-irradiation examination (PIE) techniques for reactor fuel was held in Workington, United Kingdom, with the participation of 46 experts from 17 countries. The meeting provided a forum for the exchange of views and represented a continuation of earlier Agency meetings (in 1981, 1984 and 1987) in the area of PIE. One of the conclusions from the meeting was that since 1984 there has been an improvement in hot cell capabilities for PIE of power reactor fuel. Also, more emphasis is being placed on non-destructive PIE because of the need to reduce radiological exposure and to avoid the costs associated with the transport of radioactive material and disposal of wastes.

High burnup

Fifty-five experts from 16 countries participated in the Technical Committee meeting on fuel performance at high burnup for water reactors. It was recognized that the operation of LWR fuel to extended burnup is of prime interest to the nuclear industry and has thus been the subject of intensive research.

International conference on fuel fabrication

In the area of fuel fabrication, an international conference on the characterization and quality control of nuclear fuel was organized by the Kernforschungszentrum Karlsruhe in Germany with the co-operation of the Agency. Eighty-eight participants from 29 countries attended. The majority of the papers dealt with oxide nuclear fuel and zirconium alloy cladding. An important result of the meeting was the recognition that in fuel fabrication the emphasis has shifted from the development of control methods to industrial applications. A seminar on advanced methods for fuel characterization and quality control was organized following the conference. The seminar was intended to provide participants from developing countries with nuclear power programmes with the opportunity to obtain detailed information on the different stages of fuel control and characterization.

Gadolinium bearing fuels

An updated version of a review on the quality control of mixed oxides and gadolinium bearing fuels for light water reactors was prepared by a group of experts. The report will be published in early 1991.

WREBUS

A report on the technico-economic aspects of an improved scheme of fuel utilization within the framework of the Water Reactor Extended Burnup Study (WREBUS), which is focused primarily on the assessment of the economics of high burnup operation, is now complete and will be submitted for publication in 1991.

The reliability of fuel element components was examined in a study on the mechanistic understanding of zirconium alloys in nuclear power plants. A large volume of data was analysed by a group of experts and a review is being prepared for publication.

BAF

A CRP on the technology and performance of integrated burnable absorbers for water reactor fuel (BAF) had its first research co-ordination meeting in 1990, devoted to the strategy and economics for this type of fuel, fuel properties, manufacturing, behaviour under irradiation, modelling, design and the impact on the fuel cycle. The structure and content of the final report and the contributions of the participating Member States were also discussed.

Plutonium database

A new database on plutonium worldwide was prepared. It gives an assessment of the cumulative quantity of plutonium formed in civilian reactors worldwide up to 1988 and the corresponding forecasts to the year 2010. The calculations and forecasts were based on information on electricity production derived from PRIS and were carried out with the Fuel Cycle Balance program. This material has also been used to prepare a ^{137}Cs and ^{90}Sr database, which in the future can be used to complete the fuel cycle balance calculation.

Technical co-operation

As part of a demonstration exercise to place research of interest to industrial nations in the laboratories of developing countries, the Agency, through the IWGFPT, initiated a CRP on grain size determination in zirconium alloys. The host laboratory is Siemens AG of Erlangen, Germany, with counterpart laboratories from China, Czechoslovakia, Indonesia and Mexico.

Seven technical co-operation projects dealing with various aspects of fuel fabrication and performance were supported in 1990.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Investigations on water chemistry control and coolant interaction with fuel and primary circuit materials in water cooled power reactors (WACOLIN)	1991	20
1989	Technology and performance of integrated burnable absorbers for water reactor fuel (BAF)	1994	9

CRPs established in the current year

Subject	No. of years	Participating institutions
Grain size determination of zirconium alloys	2	4

Publications

Series and No.	Title
IAEA-TECDOC-577	Advanced fuel technology and performance: current status and trends
IWGFPT/33	Ninth plenary meeting of the International Working Group on Water Reactor Fuel Performance and Technology
IWGFPT/34	Fundamental aspects of corrosion on zirconium base alloys in water reactor environments
IWGFPT/35	Recycling of plutonium and uranium in water reactor fuels

Spent fuel management

Current status and prospects

A meeting of the Regular Advisory Group on Spent Fuel Management was held to review the current world situation in spent fuel management, to define the most important directions of national efforts and international co-operation in this area, as well as assisting the Agency in the formulation of its programme. The report, Spent Fuel Management: Current Status and Prospects 1990, published as IAEA-TECDOC-580, was the result of this meeting.

Glossary

To improve the level of understanding between specialists from different countries, work was initiated on a glossary of terms related to spent fuel storage, in English, French, Russian and Spanish.

International seminar

A seminar was held jointly by the Agency and OECD/NEA on the safety, engineering and environmental aspects of spent fuel storage. Five important areas were discussed: national approaches and strategies of spent fuel management; spent fuel storage technologies, demonstration and operating experience; safe storage and reliability of spent fuel; research and development activities; and the economics and licensing of spent fuel storage technologies and facilities. Over 100 specialists from 30 countries and 4 international organizations attended.

Post-accident management of spent fuel

As the contribution to the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, Agency activities were focused on the following programmes:

- Preparation of a publication, on the management of severely damaged fuel and related wastes, containing a summary of lessons learned from relevant accidents;
- Compilation of a catalogue on post-fuel-damage recovery methods, tools and techniques, which is being prepared for publication;
- Preparations for a workshop, planned for 1991, which will present and discuss the insights and lessons learned from previous fuel damage events.

Safe spent fuel storage (SSFS)

At the beginning of 1990, about 70 000 t of heavy metal (HM) of spent LWR and HWR fuel had been discharged worldwide from nuclear power plants. Only a small fraction of this fuel has been reprocessed. Studies carried out by the Agency have projected that annual spent fuel arisings will reach nearly 15 000 t HM in the year 2005 and the cumulative arisings will be more than 300 000 t HM.

Responding to this need, the Agency began preparation of Safety Guides and Practices for the safe long term storage of spent fuel. During two consultants meetings and one Advisory Group meeting, the structures of three documents (two Safety Guides and one Safety Practice) and their contents were discussed. The first draft of a Safety Guide on the design of spent fuel storage was also prepared.

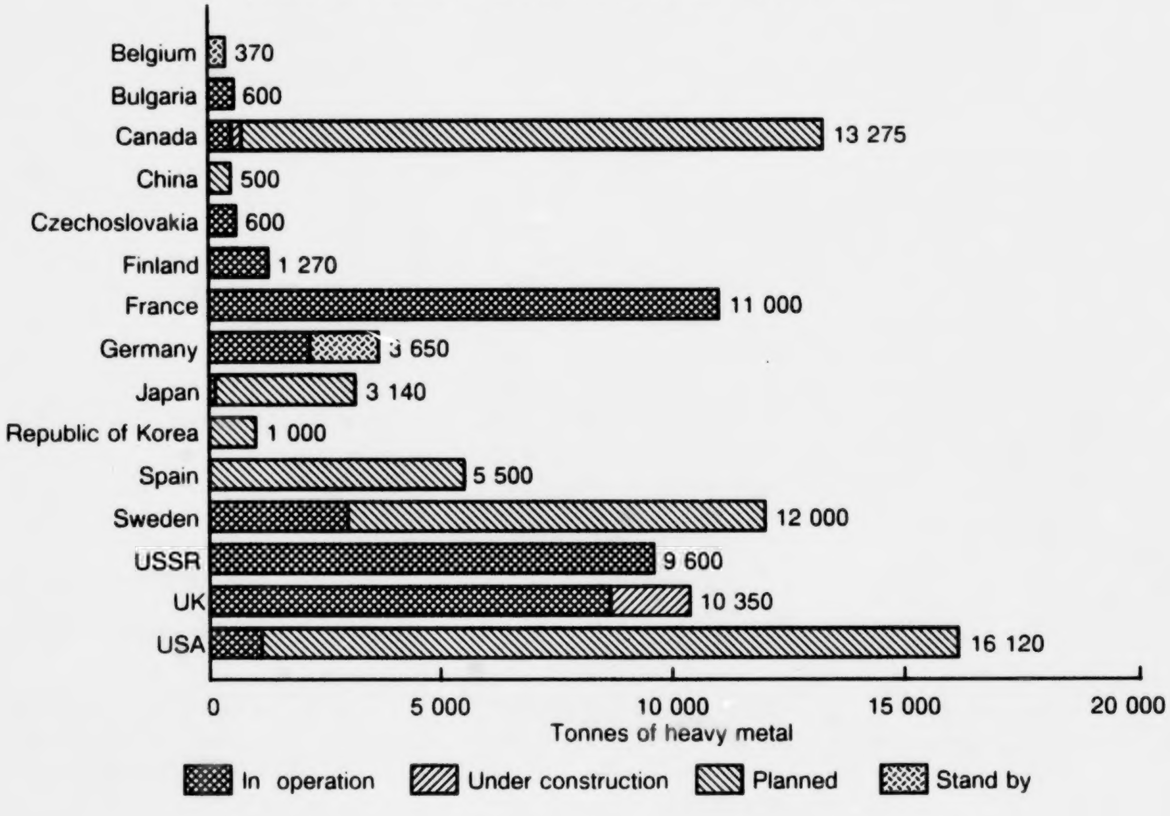
CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Behaviour of spent fuel and storage facility components during long term storage (BEFAST-II)	1991	16

Publications

Series and No.	Title
IAEA-TECDOC-556	Decontamination of transport casks and of spent fuel storage facilities
IAEA-TECDOC-559	Methods for expanding the capacity of spent fuel storage facilities
IAEA-TECDOC-580	Spent fuel management: current status and prospects 1990
	Spent fuel management newsletter No. 1

AWAY FROM REACTOR STORAGE CAPACITIES



Radioactive waste management

RADWASS

The Agency's new Radioactive Waste Safety Standards (RADWASS) programme was presented to the September meeting of the Board of Governors as a GOV/INF paper. RADWASS has high priority within the Agency's waste management programme as it will produce a new series of safety documents to set out internationally agreed upon approaches to the safe management and disposal of radioactive wastes. The series will encompass safety related documents in the fields of planning, pre-disposal, disposal, uranium and thorium waste management and decommissioning, and will be headed by a single fundamentals category document consisting of the basic safety principles of radioactive waste management. While full programme implementation is planned to begin in 1991, preparations were initiated in 1990 for the production of several of the high priority Standards and Guides in the Series.

WAMAP

Under the Radioactive Waste Management Advisory Programme (WAMAP), six regular missions to developing Member States and one special mission were conducted. WAMAP offers advisory services to Member States needing advice on establishing national waste management programmes and technical assistance on specific waste management issues or problems. A special WAMAP mission, requested by the Government of Brazil to provide assistance on the problem of the safe management and disposal of radioactive wastes resulting from the Goiânia spent sealed source accident, took place in December.

Collective opinion on safety assessment methodologies

As a direct result of information presented during a waste management symposium jointly organized by the Agency, CEC and OECD/NEA in Paris during October 1989, a collective 'opinion' on safety assessment methodologies was developed by the advisory committees at the OECD/NEA (Radioactive Waste Management Committee (RWMC)) and the Agency (International Radioactive Waste Management Advisory Committee (INWAC)). This opinion was endorsed by CEC experts and is a landmark statement regarding the status of the scientific evaluation of radioactive waste repositories. One important conclusion of the opinion is that the appropriate use of safety assessment methods, coupled with sufficient information from potential disposal sites, would offer to society a satisfactory level of safety for both current and future generations.

Public understanding of waste management issues

The growth of nuclear power in some parts of the world has basically stopped, in part because of the issue of radioactive waste disposal. During 1990, development and preparation activities continued on a source book containing basic information on radioactive waste management for use by those involved in communicating with the public. In addition, the source book can assist Member State officials in guiding the development of communication programmes for helping the public to better understand the concept of radioactive waste disposal.

Waste management information

Waste Management Research Abstracts No. 20 was issued in October. The document contains over seven hundred abstracts that describe ongoing waste management research and development in 32 Member States and international organizations.

Waste management information (cont.)

In response to the needs of Member States for information on the various activities in the field of radioactive waste management, the Agency has developed and is implementing a computer based information system — the Waste Management Data Base (WMDB). By the end of 1990 the database will have accumulated information on the waste management programmes of 64 Member States. A status report is being prepared for publication.

Publications

Series and No.	Title
IAEA/WMRA/20	Waste Management Research Abstracts No. 20
IAEA-WATRP-90	Handbook for WATRP reviews
	Effects on the environment of the dumping of nuclear wastes

Handling, treatment, conditioning and storage of radioactive wastes

Conditioning of spent fuel for final waste disposal

To reflect the significant degree of research and development work performed by several Member States on the processing of spent fuel for direct disposal, the Agency developed two Technical Reports Series publications. The first one, which will be published in 1991, evaluates spent fuel as a final waste form, while the other, which is still being prepared, describes the current concepts for the conditioning of spent fuel for disposal. As a result of this work, it was found that some additional engineering developments were still necessary to bring spent fuel disposal technology to the stage of development required for licensing a disposal facility.

Evaluation of waste forms and packages

The properties of solidified waste forms and packages were studied in two CRPs on the performance of high level waste forms and engineered barriers under repository conditions. The main feature of these CRPs was the volume of data acquired which could be used in the safety assessment of radioactive waste repositories and in long term forecasts of the behaviour of radioactive waste packages. The full results were summarized in the final reports of these CRPs.

Spent radiation sources

In response to a request from Member States, a comprehensive status report on the nature and magnitude of the problems with spent radiation sources is being prepared. As a follow-up to this, a five year Agency programme is being prepared to look at ways to improve the existing situation. The programme, which emphasizes the developing countries, includes preparation of technical and safety documents, establishing a generic database package and expert missions to locate, collect and help condition spent radiation sources. Some parts of the programme have already been initiated.

Centralized Waste Processing and Storage Facility (WPSF)

The design for a Centralized Waste Processing and Storage Facility (WPSF) is proceeding under a contract between the Agency and a commercial architect-engineer firm. The needs of most developing countries in waste management from nuclear applications are similar and detailed Agency requirements covering preferred processes are presented in this comprehensive reference design package, which is based on simple, reliable and cost effective technology. The supporting documentation for the WPSF will be completed in the first half of 1991.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Use of inorganic sorbents for liquid radioactive waste treatment and backfill for underground repositories	1991	12

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on the management of radioactive wastes	France	25	3 weeks

Publications

Series and No.	Title
Technical Reports Series No. 307	Management of abnormal radioactive wastes at nuclear power plants
IAEA-TECDOC-548	Handling, conditioning and disposal of spent sealed sources
IAEA-TECDOC-568	Evaluation of low and intermediate level radioactive solidified waste forms and packages

Radioactive waste disposal

Post-accident entombment technology

The Agency completed two reports on post-accident entombment technology which provide a review of sealing requirements for failed or damaged nuclear facilities resulting from severe accidents, and the performance of the seals and the impact of such accidents on the environment. The publications cover safety and performance assessments of radioactive waste isolation systems, the near field effects of sealed nuclear facilities, and the evaluation and optimization of post-accident confinement systems for nuclear facilities. They will be published in 1991.

Disposal technology

Preparation of a publication on the state of the art in the underground disposal of radioactive wastes was completed. The report summarizes the programmes of Member States to dispose of radioactive wastes by near surface and geological disposal. It provides descriptive information and references describing the experience of Member States with the near surface disposal of low level and short lived intermediate level wastes. Also discussed are national and international R&D and national site selection programmes for the safe disposal of high level and long lived intermediate level (alpha bearing) radioactive wastes. The report will be published in 1991.

Application of exemption principles

Work continued on the implementation of the 1988 international consensus on exemption principles. In 1991, results of the studies on very low level radioactive waste disposal, on the recycle and reuse of materials and on wastes from isotope uses in hospitals and research establishments will be used as the basis for deriving a set of universally applicable exempt quantities.

London Dumping Convention

The Agency continued to fulfil its role as adviser to the London Convention on the Prevention of Marine Pollution. At the 1990 meeting of the Convention, reports were presented on risk comparison, comparisons of land versus sea disposal options, the effects of low level radiation on man and an inventory of the disposal of packaged wastes.

Environmental impact of radioactive waste disposal

An assessment study which evaluates the impact of radiation from controlled waste disposal practices on natural plant and animal communities was completed and will be published in the Technical Reports Series. The study provides support for the generally held view that protecting man from radiation also provides adequate protection for other species, although it recognizes that sufficient information is not available in some areas.

ILMR

As in previous years, the International Laboratory of Marine Radioactivity (ILMR) assisted laboratories engaged in the analysis of different man-made and natural radionuclides in materials of marine origin by producing reference samples and executing intercomparison exercises on a worldwide basis. As a consequence of these exercises more than 120 laboratories in developed and developing countries have been able to assess the accuracy of their radiological results.

In-service training

Staff from the ILMR provided laboratory and field training in marine sampling and low level radioactivity separation and measurement techniques and gave fellowship assistance for a study on the transfer of natural radionuclides in marine food chains.

Status of marine intercomparison exercises

Sample description	Status	No. of participants
IAEA 352 Tuna fish	Completed 8/1990	74
IAEA 368 Coral sediment	Distributed 1/1990	121
IAEA 367 Coral sediment	Distributed 1/1990	107
Irish Sea mussels	Collection in early 1991	
Baltic Sea seaweed	Collection in early 1991	
Indian Ocean sediment	Collection in early 1991	

In-service training (cont.)

Technical support was also provided for training activities in marine contaminant and sediment transport in southeast Asian Member States. The project, which will continue through 1992, examines the problems of the transport of contaminants and redistribution of sediments on a local and regional scale using measurements of marine radioactivity and related parameters. A report on global and/or regional dose assessment from radionuclides in the marine environment will be prepared after the final meeting for this CRP in 1992.

Global measurements of the vertical flux of radionuclides

The ILMR participated in several oceanographic cruises in the Mediterranean to measure the downward vertical flux and changes in the inventories of radionuclides and other elements in differing marine environments. The different samples collected for the analysis of radionuclides include seawater, sediment cores, material from particle trap collectors and material filtered from seawater using in situ pumps.

In collaboration with French scientists under the DYFAMED Programme, the ILMR was responsible for carrying out time series flux measurements at a permanent French station in the middle of the Ligurian Sea. Participation in another French programme, FRONTAL, has permitted assessment of the processes that control particle flux in a dynamic ocean front system off Corsica.

A third study, in the central western basin off the Rhône River, was initiated in collaboration with the EEC sponsored European River-Ocean Systems Programme (EROS-2000). This large international study seeks to quantify riverine and atmospheric inputs of carbon and man-made contaminants to coastal waters and their subsequent downward transfer to the coastal margins. Similar particulate samples obtained on earlier cruises in 1988 and 1989 were analysed for various radionuclides, carbon and nitrogen and a synthesis of the results was initiated.

In separate laboratory tracer studies, the ability of organic detrital particles produced by plankton metabolic activities to absorb and transport radionuclides as they sink through the water was assessed. A new tracer project was initiated which seeks to delineate organic and inorganic carbon fixation by marine phytoplankton, since sinking microalgae may be a major mechanism by which greenhouse gases such as CO_2 are removed from the upper layers of the ocean. Data from these field and laboratory measurements will be used to develop models which will help predict the removal of artificial radionuclides and other materials from surface waters as well as delineate their movement through

Global measurements of the vertical flux of radionuclides (cont.)

marine biogeochemical cycles. All of these activities fall within the scope of the Joint Global Ocean Flux Study, an international programme focused on determining the global fluxes of carbon and other materials.

Radionuclides in food chains

Field and laboratory radiotracer studies were carried out in co-operation with Denmark, the EEC (Ispra), France, Portugal and the USA to measure the transfer of natural and artificial radionuclides in various marine food chains. Natural radionuclide measurements in organisms from hydrothermal vents in the north Atlantic have shown some of the highest levels of radioactive lead and polonium ever measured. Radiation doses to these deep sea species are up to one hundred times the maximum levels permitted for man. In other comparative radiotracer and field studies, it was found that edible mussels from the Mediterranean Sea accumulate many radionuclides more slowly than do the same species living in Baltic waters, owing primarily to differing environmental factors in the two regions. This suggests that Mediterranean mussels would become less contaminated than Baltic mussels following similar exposures to radionuclides entering the sea. More attention was devoted to the bioaccumulation and assimilation of ingested radionuclides in microscopic zooplankton, which form a large part of the oceanic biomass. Such studies have underscored the usefulness of laboratory radiotracer experiments to simulate what would occur in the event of radionuclide release into marine waters, and have furnished data to help interpret concentration factors routinely measured in radionuclide monitoring programmes of Member States.

Measurements are being completed, in collaboration with scientists from the Netherlands, of transuranics and other radionuclides in deep sea organisms collected from the northeast Atlantic waste disposal site.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Validation of models for the transfer of radionuclides in terrestrial, urban and aquatic environments (VAMP)	1993	17

CRPs established in the current year

Subject	No. of years	Participating institutions
Safety assessment of near surface radioactive waste disposal facilities (NSARS)	4	14
Performance of engineered barrier materials in near surface waste disposal facilities	5	14

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on strategies and methodologies for applied marine radioactivity studies	Italy	18	3 weeks

Publications

Series and No.	Title
Technical Reports Series No. 310	The environmental behaviour of radium
Technical Reports Series No. 319	Sealing of underground repositories for radioactive wastes
IAEA-TECDOC-557	Estimation of radiation risks at low dose
IAEA-TECDOC-560	Qualitative acceptance criteria for radioactive wastes to be disposed of in deep geological formations
IAEA-TECDOC-562	Low level radioactive waste disposal: an evaluation of reports comparing ocean and land based disposal options
IAEA-TECDOC-563	Siting, design and construction of a deep geological depository for the disposal of high level and alpha bearing wastes
IAEA-TECDOC-579	Migration and biological transfer of radionuclides from shallow land burial

Decontamination and decommissioning of nuclear installations

International guidance

In the area of the establishment of international standards and criteria, a Safety Guide (Safety Series No. 105) was published on the regulatory process in decommissioning. Efforts are also under way to prepare another report to provide guidance on the unrestricted release of materials, facilities or sites from decommissioning.

Technology review

In order to provide an up to date review of the technology, a report on the design, operation and application of remotely operated handling equipment in the decommissioning of nuclear facilities was submitted for publication. It will be appearing in the Technical Reports Series.

Uranium mill tailings management

To provide guidance on the design, operation and stabilization of mill tailing impoundments, an overview report which delineates the current practices in the management and confinement of such tailings was submitted for publication. As a follow-up to this work, preliminary efforts are under way to prepare another report on the decommissioning and environmental restoration of mines, mills and tailings piles.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Decontamination and decommissioning of nuclear facilities—phase II	1992	14

Publications

Series and No.	Title
Safety Series No. 105	The regulatory process for the decommissioning of nuclear facilities

Food and agriculture

Soil fertility, irrigation and crop production

Summary of CRPs

A CRP (completed in 1990) on the use of isotopes to improve the yield and N_2 fixation of grain legumes in Latin America found threefold to tenfold differences in nitrogen fixation among 20 genotypes tested in 7 countries. This indicates that large gains in yield (and savings in fertilizer) can be achieved by the selection of genotypes for this property. A similar CRP is assessing N_2 fixation in grain legumes in common use in the tropics and subtropics of Asia.

Another CRP (also completed in 1990) comparing nuclear and non-nuclear methods for measuring field soil water status showed the clear advantages of neutron moisture gauges over non-nuclear methods, which require more time and more measuring sites for an accurate estimate of average field water status. The results also contradicted previous reservations that calibration of the neutron probe was a significant constraint. The reliability of the neutron probe is a major aid in the assessment of irrigation schedules for the more effective use of scarce water resources.

A CRP on the management of nitrogen fixation by trees was initiated. Trees have a major role in maintaining soil fertility in fragile tropical soils and in combating erosion and desertification, while alleviating the fuelwood/energy crisis in many developing countries.

Another CRP was initiated in the new area of molecular biology methods (including DNA probes) in microbial ecology. Such potentially powerful techniques may be transferable to scientists in developing countries so that they can monitor the establishment and spread of specific microorganisms, especially beneficial microorganisms.

Symposium

A symposium on the use of stable isotopes in plant nutrition, soil fertility and environmental studies was held in Vienna. One hundred and fifty scientists from 40 countries attended. The topics discussed included the efficiency of agricultural production with low inputs and minimum environmental impact, genotypic differences in nitrogen use and water use efficiency, monitoring of air pollutants, sulphur and nitrogen recycling and CO_2 changes in the atmosphere. The proceedings are in the process of publication.

Laboratory activities

The Soil Science Unit provided 68 person-months of training to 16 fellows and conducted one interregional training course on the use of isotope and radiation techniques in studies on soil–plant relationships with emphasis on soil water management. Services for approximately 12 000 nitrogen isotopic measurements of plant and soil samples were provided. In connection with the nitrogen fixation programmes, development work continued on the use of molecular biology techniques to monitor microorganisms in soil and the rhizosphere. Research activities focused on the adaptation of ^{15}N methodology for measuring N_2 fixation in trees. Field and greenhouse investigations on the identification of genotypes of crop species with high water use efficiency and salinity tolerance compared a newly developed carbon isotope ratio discrimination technique with conventional methods. A training manual on the use of nuclear techniques in studies of soil–plant relationships was published.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1985	Use of nuclear and isotopic techniques to improve crop production in salt affected soils	1993	10
1989	Increasing and stabilizing plant productivity in low phosphate and semi-arid and subhumid soils of the tropics and subtropics	1993	14

CRPs established in the current year

Subject	No. of years	Participating institutions
Management of nitrogen fixation by trees for enhancing soil fertility and soil conservation in fragile tropical soils	4	14
Use of molecular biology methods in microbial ecology	4	6

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on the use of isotope and radiation techniques in studies on soil-plant relationships with emphasis on soil-plant water relations and irrigation	IAEA Seibersdorf	19	6 weeks

Publications

Series and No.	Title
Training Course Series No. 2	Use of nuclear techniques in studies of soil-plant relationships (also in Spanish)
	Soils newsletter, Nos 1 and 2

Plant breeding and genetics

Symposium

A symposium gathered plant breeders from 46 countries to assess the contribution of plant mutation breeding to crop improvement over the past 25 years. In 1964, only 49 cultivars were known to have arisen with the help of experimental mutation induction. This number reached nearly 1500 by 1990, distributed among at least 90 different cultivated plant species. At the symposium, participants from several Member States reported on the economic impact of good agricultural crop cultivars (e.g. wheat, rice, maize and cotton) — of the order of millions of dollars. The proceedings will be published in early 1991.

Gene engineering

Incorporation of the promising new technologies of gene engineering in future FAO/IAEA programmes was the subject of two meetings. One was an Advisory Group meeting on the application of mutations and tracer techniques in molecular genetics for plant breeding, while the other was a consultants meeting on induced mutants in molecular genetics and biotechnology. The recommendations, which stressed the importance of molecular biology in future agricultural development and provided advice on ways to strengthen the role of biotechnology within the framework of current mutation breeding programmes, will be reflected in new CRPs in 1991 and in research and training programmes at the Agency's Laboratories at Seibersdorf.

Laboratory activities

The Plant Breeding Unit of the Agency's Laboratories continued research and development activities concerned with: (a) studies of somaclonal and radiation induced genetic variations in maize; (b) mutation induction and breeding technology for plantains, bananas, cassava and yam; and (c) mutation breeding to improve environmental stress tolerance in *Azolla*. The in vitro system for the application of nuclear mutation techniques was used in the Ethiopian staple food crop, *Ensete*. Unit scientists participated in various training courses involving more than seventy participants. The Unit also provided facilities and guidance to 13 fellowship trainees (a total of 46 person-months) in the use of biotechnology and nuclear techniques for crop improvement. The results of this research were presented at the FAO/IAEA international symposium on plant mutation breeding for crop improvement and the UNESCO conference on plant biotechnology and in 13 scientific papers.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1986	Use of induced mutations in connection with haploids and heterosis in cereals	1991	17
1987	Improvement of rice and other cereals through mutation breeding in Latin America	1991	15
1987	Use of induced mutations and in vitro culture techniques for improving crop plant resistance to disease	1991	10
1989	Improvement of basic food crops in Africa through plant breeding including the use of induced mutations	1993	23
1989	Improvement of root and tuber crops in tropical countries of Asia	1993	8
1989	In vitro mutation breeding of bananas and plantains	1993	11
1989	Mutation breeding of oil seed crops	1993	14

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on the induction and use of mutations in plant breeding	IAEA Seibersdorf	20	6 weeks
Group course on the genetic basis of mutations and related techniques for crop improvement	Poland	6	1 year
Regional course on the induction and use of mutations in plant breeding	Ghana	19	6 weeks
Regional advanced course on doubled haploids for cereal improvement in Latin America (ARCAL VII)	Guatemala	14	3 weeks

Publications

Series and No.	Title
	Mutation breeding newsletter, Nos 35 and 36
Mutation Breeding Review No. 5	Economic and agricultural impact of mutation breeding in fruit trees
Mutation Breeding Review No. 6	Mutation breeding for quality improvement — a case study for oil seed crops
Mutation Breeding Review No. 7	Induced mutations for crop improvement

Animal production and health

General

Activities were concentrated on the introduction and use of radioisotopes for assessing the feeding value of locally available agroindustrial by-products and on the use of radioimmunoassay (RIA), enzyme immunoassay (EIA) and DNA probes for measuring reproductive and metabolic hormones and for the diagnosis and surveillance of animal diseases.

Improving livestock productivity

An important development over the past year was the merger and reorientation of programmes in animal nutrition and reproduction to form one integrated component of animal production. Radioimmunoassay techniques continued to be successfully employed by over seventy counterpart institutions in Member States in Asia, Africa and Latin America, within the framework of four ongoing CRPs, in the study of problems limiting optimum animal production and the search for methods for overcoming them using indigenous feed and other resources. The studies concentrated on indigenous and upgraded breeds of livestock kept by smallholder farmers in tropical or subtropical countries and involved work on cattle, sheep, goats, buffaloes and camelids. These studies demonstrated the important role that inadequate nutrition and poor management practices play in limiting the overall productivity of farm animals. Research programmes and technical co-operation projects on cattle and goats have shown that substantial increases in growth, milk production and reproductive efficiency can be obtained by the strategic use of urea–molasses blocks as supplementary feed during critical periods, while work on buffaloes has demonstrated that better fertility can be obtained simply and at no extra cost by adopting new management practices, such as the unrestricted suckling of calves.

Arising from this work is the need for quantifiable and sensitive indices for monitoring the nutritional status of animals and for predicting the responses of animals to nutritional supplements (e.g. energy, protein and minerals). Efforts are therefore being made through CRPs to develop and evaluate techniques for measuring the concentration of selected metabolites and hormones in body fluids with a view to diagnosing nutritional imbalances. These methods will be tested under future field programmes for their value in supplementing traditional methods.

Diagnosis and surveillance of livestock diseases

Veterinary investigation centres in over forty Member States were assisted in their efforts to diagnose and control animal diseases through the introduction of immunoassay tests which, as a result of FAO/IAEA supported research conducted over the past two years, were shown to be more sensitive and specific than tests used previously, and had the additional advantages of being cheaper and easier to use. Livestock in large areas of Africa were screened using an immunoassay test kit for antibodies to rinderpest in support of the Pan African Rinderpest Campaign funded by the EEC and OAU/Inter-African Bureau for Animal Research (IBAR), and a similar test for trypanosomiasis is currently used to support national and regional control and eradication programmes in Africa and Asia. FAO/IAEA immunoassay tests were validated for the diagnosis of brucellosis and bluetongue and approved for use by WHO and the International Office of Epizootics (OIE), respectively. Tests for other diseases, such as foot and mouth disease, babesiosis and leukosis, were also validated and computer software programs for analysing immunoassay test results were developed

Diagnosis and surveillance of livestock diseases (cont.)

and counterpart staff trained in their use. A training manual was prepared, for inclusion in immunoassay test kits, on immunoassay methods and their use in the diagnosis and surveillance of animal diseases.

Laboratory activities

The Animal Production Unit of the Agency's Laboratories continued to provide technical support, primarily through the production and distribution of standardized and validated clinical and diagnostic kits. Radioimmunoassay kits for the measurement of the reproductive hormone progesterone in milk and blood were distributed to approximately seventy counterpart laboratories. Colorimetric, RIA and selective ion kits for the measurement of eight metabolic parameters were developed and are in the process of final standardization and validation. They will be used to assess and monitor the nutritional status of indigenous livestock species. Enzyme linked immunosorbent assay kits for the diagnosis of infectious diseases were provided, with priority given to six major diseases: rinderpest, brucellosis, foot and mouth disease, babesiosis, trypanosomiasis and bluetongue.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Regional network for Latin America on animal disease diagnosis using immunoassay and labelled DNA probe techniques	1991	15
1987	Serosurveillance of rinderpest and other diseases in Africa using immunoassay techniques	1991	24
1988	Development of feeding strategies for improving ruminant productivity in areas of fluctuating nutrient supply through the use of nuclear and related techniques	1991	19
1988	Strengthening animal disease diagnosis in Asia through the application of immunoassay techniques	1993	12
1988	Strengthening animal reproduction research in Asia through the application of immunoassay techniques	1993	13
1988	Improving the productivity of indigenous African livestock using radioimmunoassay and related techniques	1993	18
1988	Improving the diagnosis and control of trypanosomiasis and other vector borne diseases of African livestock using immunoassay methods	1993	13
1989	Development of feed supplementation strategies for improving ruminant productivity on smallholder farms in Latin America through the use of immunoassay techniques (ARCAL III, Phase II)	1994	19

CRPs established in the current year

Subject	No. of years	Participating institutions
Interregional network for improving the productivity of camelids	5	15

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on the use of immunoassay techniques in the diagnosis and control of animal diseases	Côte d'Ivoire	22	4 weeks
Regional course on radioimmunoassay and enzyme immunoassay for the determination of hormones, metabolites and antibodies in animal production and health	Cuba	16	2 weeks
Regional course on the application of immunoassay and related techniques in studies on animal production and disease control in Asia	Indonesia	20	4 weeks
National course on immunoassay methods for the diagnosis and surveillance of animal diseases	Venezuela	15	2 weeks
Regional course on the use of immunoassay and DNA probes for the diagnosis of animal diseases (in association with IFS)	Costa Rica	54	2 weeks

Publications

Series and No.	Title
Panel Proceedings Series	Domestic buffalo production in Asia
Panel Proceedings Series	Feeding strategies for improving productivity of ruminant livestock in developing countries
Panel Proceedings Series	Livestock reproduction in Latin America using radioimmunoassay techniques
Panel Proceedings Series	Studies on the reproductive efficiency of cattle

Insect and pest control

Fruit flies

Fruit flies are a major pest in most of the developing world. They destroy fruits and vegetables, impede exports and cause the heavy use of insecticides. Sexually sterile fruit fly males can be released into orchards to suppress the reproduction of wild fruit flies, thereby protecting the fruit. Since female fruit flies damage fruit in their attempts to insert eggs, genetically modified strains of the Mediterranean fruit fly (medfly) have been devised in which females can be removed readily from mass rearing cultures. By releasing only sterile males, it was found that the sterile insect technique (SIT) could be used to protect fruit very effectively. This was done in 1989 and 1990 on a trial basis in Israel as part of a CRP and fully satisfactory results were obtained. Significant advances in the mass separation of female medflies from males, in mass rearing and in the means of detecting and monitoring populations are also being made.

The trials involved sexually sterile male medflies (from a strain in which females had been removed by genetic means) which were field tested between June and December. Each week 2.5 million male pupae were produced at the Agency's Laboratories at Seibersdorf and shipped to Israel for release. The removal of females is readily achieved because in this strain all female pupae are white and all male pupae brown. Excellent protection of citrus fruit was achieved. The sterility rate among wild females was higher when only sterile males were released than when both sterile males and females were released. These results are likely to increase the demand for the use of SIT for medfly control in countries with fruit export industries.

Tsetse flies

Tsetse fly transmitted trypanosomiasis continues to be a scourge affecting 37 countries in sub-Saharan Africa. The threat of African animal trypanosomiasis can be removed by the elimination of the tsetse vectors. The sterile insect technique is a valuable component of integrated action and is being pursued through pilot programmes in Ghana, Nigeria, Tanzania, Uganda and Zambia.

Laboratory activities

Work continued in the Entomology Unit of the Agency's Laboratories to develop and improve the cost effectiveness of SIT for control of the medfly and the tsetse fly. Such work included initiation of studies on the New World Screwworm.

A new method of removing female medflies, based on the differential temperature sensitivity of male and female embryos, is being developed for field evaluation. In the new genetic strain, females can be eliminated by exposing the eggs to heat, permitting a reduction in rearing costs of almost fifty per cent. Techniques for reusing expended bran bulking agent in the larval rearing medium were developed and transferred to mass rearing factories in Mexico and Guatemala. This has resulted in large savings. Advances were also made in using an inert, reusable substrate with a nutrient solution. In addition, an effort is being made to introduce environmentally friendly biological control agents to replace insecticides now used to reduce wild populations preparatory to the release of sterile males. Isolates of the entomopathogen *Bacillus thuringiensis* were discovered that produce various soluble principles that kill adult medflies. These principles are being characterized chemically prior to evaluation of their safety for non-target organisms. A search is being made for middle repetitive DNA in the genome of the medfly to find transposable elements with the potential for use as transformation vectors.

Laboratory activities (cont.)

Colonies of six species of tsetse fly were variously stabilized and maintained at levels ranging from 1000 to 150 000 female flies to provide insects for sterilization and release in test sites in Africa, for backup for research programmes at the Agency's Laboratories at Seibersdorf and other centres in Europe and for training purposes. Techniques were developed to transport up to 70 000 viable pupae per month to project sites in Africa. A new technique requiring less labour was developed to determine the quality of tsetse fly blood diets. The radiosensitivities of newly colonized species intended for SIT programmes were determined. Research is also under way to find sex related differences among immature stages, which can be used to separate sexes. The effects and biology of apparent viruses in tsetse flies are being examined, as are inheritable factors that distort sex ratios in colonies.

Equipment and techniques were developed and tested to measure the effects of long distance transport on the quality of screwworm flies. Three devices that measure and record fluctuations in temperature, humidity and the jarring experienced by sterile flies during shipment were made available for operational use.

Forty person-months of training was provided to fellows and cost free interns. In addition to insects provided to projects and collaborating research institutions, freeze-dried diet components for insect rearing were produced and shipped to technical co-operation projects in Africa.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Standardization of medfly trapping for use in sterile insect technique programme	1991	9
1987	Radiation induced F-1 sterility in lepidoptera for area wide control	1991	11
1988	Laboratory and field evaluation of genetically altered medflies for use in sterile insect technique programmes	1993	13
1989	Development of practices for area wide tsetse eradication or control with emphasis on the sterile insect technique	1994	12
1989	Genetic engineering technology for the improvement of the sterile insect technique	1993	7

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on integrated control of tsetse flies with emphasis on the sterile insect technique	Ghana	19	4 weeks
Interregional course on the use of isotopes and radiation for insect control with special reference to the sterile insect technique	USA	20	6 weeks
National course on the use of nuclear techniques in entomology	Malaysia	21	10 days

Publications

Series and No.	Title
Panel Proceedings Series	Genetic sexing of the Mediterranean fruit fly
Panel Proceedings Series	Sterile insect technique for tsetse control and eradication

Agrochemicals and residues

General

The agrochemicals programme continued to assist Member States in dealing with problems related to pesticide use practices with a view to improving their efficacy, reducing hazards to consumers and protecting the agricultural environment.

Pesticide residues in food and the environment

The programme on monitoring pesticide residues in food and the environment developed and introduced radiotracer aided research methods suitable for evaluating local agricultural practices for the identification of problems related to pesticide use, for monitoring pesticide residues in the agricultural environment and for the preparation of controlled release formulations of pesticide chemicals. There were five CRPs which were concluded covering pesticide residues in livestock products, stored grain, food plants, pesticide residues bound to biological substrates and the behaviour of persistent pesticides in the tropics.

Laboratory activities

The Agrochemicals Unit of the Agency's Laboratories provided 32 person-months of training to fellows and cost free interns in the use of radioisotope techniques in research on agrochemicals. Staff of the Unit participated in the CRP on the development of controlled release (CR) formulations of pesticides utilizing nuclear techniques.

Research and development activities included preparation and evaluation of new CR formulations of butachlor and thiobencarb herbicides. When compared with leading commercial formulations, some of the new CR alginate formulations showed better herbicidal activity against *Echinochloa crusgalli* (a major weed of rice paddy), reduced phytotoxicity to rice seedlings and reduced toxicity to fish. Using radioisotope techniques, it was shown that the loss of herbicides by evaporation was much less from CR formulations than from commercial formulations.

Considerable progress was made in the stabilization of pyrethroid insecticides for use in the integrated control of tsetse flies. New deltamethrin formulations are undergoing field evaluations for tsetse fly control in Ghana, Kenya and Tanzania. A sprayable emulsifiable concentrate formulation was also developed and is undergoing evaluation for stability under simulated tropical environmental conditions. Three scientific papers related to this research were submitted for publication and papers were presented at the Third Workshop on the Study and Prediction of Pesticide Behaviour in Soils, Plants and Aquatic Systems and the IUPAC International Congress on Pesticide Chemistry.

The Unit also started providing technical support to the screwworm eradication programme in North Africa. An adult screwworm suppression system containing an insecticide and a bait is being developed for use in this programme.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Use of isotopes in studies of pesticides in rice/fish ecosystems — phase II	1991	7
1986	Biological activity and bioavailability of bound pesticide residues using nuclear techniques	1991	8
1988	Development of controlled release formulations of pesticides utilizing nuclear techniques	1993	15
1988	Radiotracer studies to reduce or eliminate pesticide residues during food processing	1993	13
1989	Radiotracer studies of the behaviour of DDT in tropical environments	1994	12
1989	Radiotracer studies to reduce or eliminate pesticide residues during food processing	1994	12

CRPs established in the current year

Subject	No. of years	Participating institutions
Adverse effects on flora and fauna from the use of organochlorine pesticides on the African continent	5	6

Publications

Series and No.	Title
Proceedings Series	Environmental contamination following a major nuclear accident
Panel Proceedings Series	Studies of the magnitude and nature of pesticide residues in stored products using radiotracer techniques
IAEA-TECDOC-554	Radiotracer studies of fungicide residues in food plants

Food preservation

ICGFI

In complying with its mandate, the International Consultative Group on Food Irradiation (ICGFI) has continued to provide information and advice to member countries, the FAO, the Agency and WHO in the areas of the safety assurance of the process, legislation, techno-economic feasibility, training, trade and public information. An international inventory of authorized food irradiation facilities has been established by the ICGFI to provide a credible list of properly licensed, operated and controlled facilities. Twenty-one facilities in 14 countries are included in the inventory for 1990. Eight ICGFI Codes of Good Irradiation Practice for specific applications of food irradiation (e.g. sprout inhibition of roots and tubers, control of pathogens in poultry and meat, insect disinfestation of grain, dried fish and fresh fruits, etc.) were adopted for publication. An ICGFI Network for Training on Food Irradiation (INTFI) was established by inviting various suitably equipped institutions to collaborate and contribute towards joint training programmes. Initially, 15 institutions in both developed and developing countries will be invited to collaborate under the scope of INTFI. The Governments of Bulgaria, Costa Rica, Peru and Viet Nam have become members of ICGFI, bringing the total membership to 37.

IFFIT

The International Facility for Food Irradiation Technology (IFFIT), established in 1978 under an agreement between the FAO, the Agency and the Ministry of Agriculture and Fisheries of the Netherlands, completed its mandate and ceased operation on 31 December 1990. During its tenure, IFFIT organized 14 regional and interregional training courses, several workshops and short courses on various aspects of food irradiation. A total of some five hundred scientists and officials from more than forty countries attended IFFIT's training programmes. Thus, IFFIT contributed effectively to the transfer of the technology to developing countries. The impetus generated by IFFIT is being followed up closely by ICGFI through its Network for Training on Food Irradiation.

Insect disinfestation of fresh produce to satisfy quarantine regulations

To assist Member States in overcoming quarantine restrictions in the trade in fresh agricultural produce, especially against the fruit fly and other pests, a CRP on this subject (involving 14 institutions) was conducted from 1986 to 1990. Research results showed that a minimum dose of 150 Gy can be effective for disinfesting any species of fruit fly without affecting the quality of host commodities. A minimum dose of 300 Gy can be used for disinfesting other insect species (e.g. mango seed weevil) and mites in fresh produce to satisfy quarantine regulations. The data from this CRP are needed by the food industry and by regulatory agencies in view of the prohibition of ethylene dibromide for fumigating fresh produce to overcome quarantine barriers. The United States Department of Agriculture has accepted irradiation as a quarantine treatment against fruit fly infestation of Hawaiian papaya. The North American Plant Protection Organization, representing national authorities in Canada, Mexico and the USA, has also accepted irradiation as a quarantine treatment of fresh agricultural produce.

Practical applications

The practical application of food irradiation, while still limited, has shown a significant increase in 24 countries. Among food items for commercial use, spices and dried vegetable seasonings are being treated in 17 countries. While there are 47 demonstration/commercial food irradiators being used to treat food for commercial purposes, the first commercial food irradiator in North America is under construction in Florida, USA, to treat various food items approved in that country. The first commercial food irradiator in Africa is under construction in Abidjan, Côte d'Ivoire.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Use of irradiation to control infectivity of food-borne parasites	1991	13
1989	Food irradiation programme for Middle East and European countries	1993	12
1989	Application of irradiation techniques for food processing in Africa	1993	10

CRPs established in the current year

Subject	No. of years	Participating institutions
Analytical detection methods for irradiation treatment of foods	4	25
Food irradiation process control and acceptance in Asia	3	16
Irradiation in combination with other processes for improving food quality	5	15

Training courses and seminars held

Course name	Location	No. of participants	Duration
IFFIT general course on food irradiation	Netherlands	20	5 weeks
ICGFI food irradiation process control school (FIPCOS) for operators/plant managers	Canada	11	3 weeks
ICGFI food irradiation process control school for food inspectors/control officials	India	17	2 weeks
ICGFI workshop on the techno-economic feasibility of food irradiation for Latin America	Chile	16	2 weeks
ICGFI workshop on dosimetry techniques for food irradiation	Netherlands	12	2 weeks
FAO/IAEA workshop on the commercialization of food irradiation (for RCA countries)	China	14	1 week
FAO/IAEA/UNDP regional workshop on the techno-economic feasibility of electron beam versus isotopic sources of radiation for food processing	Japan	11	2 weeks
National course on food irradiation	China	30	2 weeks

Publications

Series and No.	Title
IAEA-TECDOC-544	Factors affecting practical application of food irradiation
IAEA-TECDOC-545	Asian Regional Co-operative Project on food irradiation: research and development
IAEA-TECDOC-576	Food irradiation for developing countries in Africa

Human health

General

Interagency consultations between the IAEA and WHO on areas of collaboration took place in Vienna. The scientific programmes of both organizations were discussed, areas of mutual interest identified and an action plan drawn up for mutual co-operation.

An expert group meeting was held to review the scientific activities of the human health programme for 1991–1992 and the forecasts for 1993–1998 (excluding dosimetry, which has its own scientific committee). The group noted that restrictions imposed by the limitation of resources had forced a high degree of selectivity, but the emphasis on the transfer of nuclear technology to developing countries had brought positive results.

Nuclear medicine

Technical co-operation

A total of 37 new technical co-operation (TC) projects in the area of nuclear medicine were evaluated for scientific support. Out of 130 TC projects in progress, 16 were completed.

Training human resources for nuclear medicine in developing countries

Fellowships in the area of nuclear medicine were awarded to 43 candidates from 25 developing countries. The candidates received training at institutions in 10 developed and 8 developing countries, accumulating a total of 180 person-months. In addition, 146 other fellows from developing countries participated in courses and workshops on different topics in the field of nuclear medicine, including medical scintigraphy, immunoscintigraphy, the use of tumour markers, radioimmunoassay (RIA) and quality control and the preventive maintenance of nuclear medicine instruments.

Enhancing research in developing countries

Three CRPs involving 35 institutions were successfully concluded. The participants of the CRP on radioaerosol inhalation imaging of the lungs for the diagnosis of respiratory diseases decided to assess a modified nebulizer assembly, developed by one of the participating institutes, in the study of the mucociliary function in the lungs. An article in the IAEA Yearbook for 1990 described the fundamentals of this programme in detail. The experience of the participants will be used to produce an atlas by the end of 1991 on aerosol inhalation lung imaging to assist physicians in the clinical interpretation of these types of images, especially in developing countries. The final outcome of the CRP on immunodiagnostic techniques in schistosomiasis was the initiation of a wide scale trial to assess the therapeutic effects of new medications. The results of the CRP on the promotion of the optimum use of bulk reagents for the RIA of thyroid related hormones, conducted by 63 laboratories in 14 Latin American countries, were: promotion of good RIA practices in the region; awareness of and commitment to quality control measures; progress towards self-sufficiency in the supply of reagents; and enhanced collaboration. In addition, this CRP heightened the feasibility of screening for neonatal hypothyroidism in iodine deficient regions. At present, ten additional CRPs on different topics of nuclear medicine are in progress in 96 institutes.

Enhancing research in developing countries (cont.)

Twenty-two scientists from developed and developing countries participated in five different consultants meetings on: immunoscintigraphic techniques in the early diagnosis of cancer in developing countries; cost effectiveness of nuclear and non-nuclear procedures for the in vitro assay of alpha-fetoprotein; nuclear cardiology; nucleic acid probes in communicable diseases; and nuclear investigations of the cerebral function. As a result, it was proposed that five new CRPs be initiated in the near future.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1986	Care and maintenance of nuclear equipment in Asia	1991	9
1987	Radioaerosol inhalation imaging for the diagnosis of respiratory diseases in developing countries	1990	11
1987	Promotion of the optimum use of bulk reagents for RIA of thyroid related hormones (ARCAL)	1990	14
1987	Immunodiagnostic techniques for the quantitative determination of circulatory and urinary parasite derived antigens in human schistosomiasis	1990	10
1987	Immunodiagnosis of tuberculosis (RCA)	1991	9
1988	Development and field application of nuclear techniques for malaria research and control	1991	11
1988	Development of diagnostic reagents for communicable diseases using radiation processing techniques	1991	6
1989	Evaluation of imaging procedures for the diagnosis of liver diseases — phase II	1992	13
1989	Optimization of nuclear techniques for the survey of the thyroid function of newborns in endemic goitre areas	1992	9
1989	Quality control and preventive maintenance of nuclear and related medical equipment in Africa	1992	12
1989	Quality control and preventive maintenance of nuclear medicine equipment in Latin America	1992	12
1989	Quality control of advanced nuclear medicine equipment in Asia	1992	8
1989	Immunodiagnosis of malaria	1992	7

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on nuclear medicine	USSR	30	2 months
Regional course on medical scintigraphy	Cuba	25	4 weeks
Regional course on radioimmunoassay methodology, quality control and data processing	Syrian Arab Republic	11	2 weeks
Regional course on radioimmunoassay methodology, quality control and data processing	Ethiopia	12	3 weeks
Seminar on nuclear techniques in the early diagnosis of cancer	Headquarters	57	1 week
Workshop on quality control and preventive maintenance of nuclear medicine instruments	India	11	2 weeks

Publications

Series and No.	Title
IAEA Yearbook 1990	Diagnosing diseases of the lung
IAEA SR-166	Application of nuclear techniques in the early diagnosis of cancer in developing countries (extended synopses)

Applied radiation biology and radiotherapy

Radiation sterilization of medical supplies

Under the programme for promoting national health care services in developing countries, there has been continued recognition of the prevailing risk in some countries of the Latin America region of patients contracting cross-infectious diseases resulting from an inadvertent clinical use of non-sterile medical items. This has served as the basis for the initiation and support in 1990 of relevant research and development capabilities within the framework of a regional CRP. The new CRP focuses on such technical aspects as the accurate estimation of the microbiological burdens of local medical supplies in Latin America and the application of suitable radiobiological criteria in the determination of their specific radiation response parameters.

Upon the conclusion of a similar regional CRP on the radiation sterilization of local medical supplies for developing countries in Africa and the Middle East region, progress was reviewed and data co-ordinated in a final research co-ordination meeting held in Accra, Ghana. A research database specific to the Africa and Middle East region was developed by means of the programme and an indigenous technical infrastructure established through training programmes.

Biological tissue graft implants, such as bone, nerve, fascia, dura and chorion amnion dressings for burn wounds have been successfully sterilized by gamma radiation in eight developing Member States of the Asia and Pacific region, in accordance with the standardized operating protocol developed by the investigators within the framework of a regional CRP. Data from another CRP just completed in this area were reviewed and co-ordinated in the final research co-ordination meeting, held in December in Cheonan, Republic of Korea. A guideline document for Member States on the radiation sterilization of disposable medical products was published as IAEA-TECDOC-539.

Biological dosimetry for radiation protection

Radiation induced chromosomal effects formed the basis in a CRP of a 'biological dosimeter' for the accurate quantitative estimation of in vivo absorbed radiation dose(s) essential for radiation protection and risk assessment operations. Biological dosimetric criteria and standards were assessed in the final research co-ordination meeting held in June in Rio de Janeiro, Brazil. The biological dosimetry system continues to be used successfully in the radiological monitoring of accidentally overexposed personnel in Member States, such as for the Goiânia accident cases in Brazil, and in cytogenetic studies on persons in contaminated areas after the Chernobyl accident in the USSR.

Radiation for sewage recycling

Radiation induced microbicidal effects, as well as other microbiological and physical/chemical alterations of solids after irradiation that affect settling qualities, were pursued in a CRP on feasibility studies for sewage treatment and safe recycling. The final research co-ordination meeting for the CRP was held in July, in Washington, D.C., in conjunction with the meeting of the North American Task Committee on Radiation Treatment of Waste and Waste Water.

Radiotherapy of cancer

Efforts are being made to improve radiotherapy facilities in developing countries through various technical co-operation programmes. For example, manpower requirements are being met through the training of radiotherapists, medical physicists and radiation technologists. In addition, cobalt teletherapy machines have been supplied to Indonesia, the Republic of Korea, Nigeria and Pakistan. Two CRPs were initiated with the aim of improving the quality and accuracy

Radiotherapy of cancer (cont.)

of treatment planning and dosimetry in radiotherapy in developing countries through the introduction of personal computer based treatment planning systems: (a) a regional CRP (RCA) on radiotherapy of carcinoma of the cervix; and (b) a global CRP on head and neck cancers. The first research co-ordination meeting on the CRP on cervix carcinoma was held in Bangkok, Thailand.

Brachytherapy project

The project on the brachytherapy of cancer of the cervix in Egypt ended with the seventh meeting of the Project Advisory Committee (Technical) (PACT), in Vienna. Implementation of similar activities in other developing countries was recommended.

Biological effects of low doses of ionizing radiation

Recently, new data on the intrinsic cellular and molecular mechanisms involved in biological effects of low doses and low dose rates of ionizing radiation were published in the literature. This research trend is reflected in low dose, radiation associated risk estimation studies and will help to clarify the existing uncertainties in dose–response relationships. A review on the subject was prepared and presented at a WHO Expert Group meeting held in Mönchengladbach, Germany, on the theoretical and experimental basis for the best estimate of low level radiation risk.

To supplement the extensive research on the effects of Chernobyl fallout on the environment and health, more scientific information regarding the radiobiological characteristics of hot beta particles is needed. A CRP on this subject was initiated with the aim of providing a database to facilitate the assessment of the potential cancer risk.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Microbiological quality control and sterility safety evaluation in radiation sterilization of local medical supplies in Latin America	1992	7
1989	Computer assisted planning and dosimetry in the radiotherapy of carcinoma of the cervix in the Asia and Pacific region (RCA)	1993	9

CRPs established in the current year

Subject	No. of years	Participating institutions
Computer assisted planning and dosimetry in the radiotherapy of head and neck cancers	2	10
Exploration of the molecular mechanism(s) of the stimulatory effect (i.e. adaptive response) of low dose and low dose rate radiation	3	12
Radiological impact of hot beta particles from the Chernobyl fallout: risk assessment	3	12

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on radiation cytogenetics applications in biological dosimetry	Brazil	22	3 weeks
Regional course on radioisotope and radiation techniques in biological sciences significant for human health problems (RCA)	Japan	16	1 month
Regional course on radiation sterilization of tissue grafts for safe clinical use	Republic of Korea	17	2 weeks

Publications

Series and No.	Title
IAEA-TECDOC-539	Guidelines for industrial radiation sterilization of disposable medical products
IAEA-TECDOC-571	Nuclear and related techniques in the improvement of traditional fermentation processing of cassava

Dosimetry

SSDLs

The number of Secondary Standard Dosimetry Laboratories (SSDLs) increased slightly to 66 laboratories in 51 Member States. The fourth meeting of the SSDL Scientific Committee was held in November. In addition to its review and evaluation of the work of the SSDL Network, the Committee also discussed the entire dosimetry programme of the Agency.

Dose intercomparison and assurance

In connection with the programme to assist Member States in the improvement of accuracy in radiotherapy, the IAEA/WHO thermoluminescent dosimetry (TLD) service was continued and 176 dosimeters were distributed to radiotherapy centres. The International Dose Assurance Service (IDAS) for radiation processing facilities was continued, with 31 participating institutions from 23 countries. A total of 93 dose checks were performed and the results showed that the accuracy of dosimetry has been significantly improved.

Development of dosimetry techniques

The national institutes of nine Member States are participating in efforts to co-ordinate methods of improving high dose electron dosimetry, to reduce measurement uncertainty and develop new dosimetry techniques. A research co-ordination meeting on quality control dosimetry for particle beam radiation processing was held in April, attended by nine participants from nine countries.

Symposium

In November, a symposium on high dose dosimetry for radiation processing was attended by 79 participants from 34 countries and 2 international organizations. The aim of the symposium was to gather and disseminate new information in the field of high dose dosimetry and applied research. Particular areas examined were: the improvement of dosimetry techniques and systems; the development of new dosimetry techniques; international co-operation for the worldwide standardization of high doses in order to utilize dosimetry as a quality control measure in radiation processing to facilitate the regulatory approval of irradiated products. The proceedings will be published in early 1991.

Dosimetry laboratory at Seibersdorf

The Dosimetry Unit of the Agency's Laboratories at Seibersdorf, as the central laboratory of the IAEA/WHO network of SSDLs, continued to respond to: service requests for routine dosimetry for hospitals and intercomparisons for SSDLs worldwide; calibration of secondary standard dosimeters/field instruments; reference irradiations; the development of intercomparison methodologies; and the training of fellows and scientific visitors. The Unit's activities increased following an expansion of the TLD service to hospitals for ^{60}Co treatment units and to medical accelerators, the introduction of the alanine/electron spin resonance (ESR) dosimetry system for dose assurance measurements at high dose facilities and the providing of reference irradiations for two CRPs.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Development of quality control dosimetry techniques for particle beam radiation processing	1993	9
1988	Testing of the code of practice for absorbed dose determination in photon and electron beams	1991	9
1989	Performance testing of dosimetry equipment	1993	8

CRPs established in the current year

Subject	No. of years	Participating institutions
Therapy level dosimetry with alanine/ESR system	4	6

Training courses and seminars held

Course name	Location	No. of participants	Duration
IAEA/EEC course on radiation therapy and dosimetry	Egypt	48	2 weeks
National seminar and workshop on clinical dosimetry of high energy photons and electrons	Thailand	30	2 weeks
ESTRO/IAEA/WHO symposium on infrastructure in radiotherapy	Italy	38	1 day

Publications

Series and No.	Title
	SSDL newsletter, No. 29

Nutritional and health related environmental studies

Nutrition

Nuclear and isotopic techniques have continued to play an important role in human nutrition studies. A new CRP was initiated to study the bioavailability of iron and zinc from human diets with the aid of isotopic tracers. This CRP aims to address the worldwide problem of the more than 500 million people — mainly in developing countries — who are suffering from iron deficiency anaemia. The underlying cause in many cases is not an absolute deficiency of iron in the diet but poor bioavailability. It is hoped to identify local foodstuffs containing bioavailable iron to study the factors promoting and inhibiting absorption and to investigate concurrent effects on the bioavailability of other trace elements, particularly zinc.

Within the framework of a CRP on the application of stable isotope tracers in human nutrition, the Agency certified 13 stable isotope reference materials and prepared documentation (in collaboration with the International Dietary Energy Consultancy Group) on the use of the doubly labelled water method for measuring energy expenditure in humans.

A database continued to grow of results for diet samples collected within the framework of the CRP on human daily dietary intake of nutritionally important trace elements as measured by nuclear and other techniques. Results were reported at two international conferences and at the WHO/FAO/IAEA Expert Consultation on Trace Elements in Human Nutrition. Although financial support for this CRP has been phased out, it will continue on a cost free basis until the end of 1991.

Environment: non-radioactive inorganic pollutants (terrestrial)

A CRP on the applicability of nuclear analytical techniques for the determination of toxic elements in foodstuffs was completed. This CRP, carried out within the RCA framework, has produced improved radiochemical separation methods and analytical quality control procedures for the elements of interest. Most of the participating institutes are now providing analytical services in support of national food monitoring programmes.

A new CRP on the assessment of environmental exposure to mercury in selected human populations, as studied by nuclear and other techniques, was started in collaboration with WHO. Its purpose is to promote national and regional studies on exposure to mercury and methylmercury in selected at-risk populations. The Agency's International Laboratory of Marine Radioactivity (ILMR) in Monaco will also support this work.

A database on biological and environmental reference materials for trace elements, nuclides and organic microcontaminants was updated. A personal computer software package was also developed for interrogating the database and is available cost free to interested users.

The Agency's Laboratories at Seibersdorf continued to provide support for the WMO Background Air Pollution Monitoring Network (BAPMoN) by acting as a sample collection, data acquisition and distribution centre.

Environment: non-radioactive inorganic pollutants (marine)

The Marine Environmental Studies Laboratory (MESL) of ILMR organized worldwide intercalibration exercises for the analyses of trace metals, chlorinated hydrocarbons and petroleum hydrocarbons in marine sediments with the participation of 166 laboratories from 57 Member States. In addition, staff from MESL (in association with UNEP) conducted five missions, to Egypt, Kuwait, Tunisia (2) and Yugoslavia, to assist in setting up quality assurance programmes in laboratories monitoring marine contaminants.

Environment: non-radioactive inorganic pollutants (marine) (cont.)

The third international organotin symposium was convened in Monaco in April, with CEC, CIESM, FAO, IAEA, IMO, the Intergovernmental Oceanographic Commission of UNESCO (IOC), UNEP and WHO as co-sponsors. In conjunction with this meeting, MESL organized an intercalibration exercise on the quantification of tributyltin (a major pollutant from marine antifouling paints) in coastal waters.

— reference methods

As part of an ongoing co-operative programme with UNEP, MESL continued to co-ordinate the development, testing and revision of reference methods and guidelines for marine pollution measurements. This work involves the co-operation of FAO, IOC, WHO and WMO.

During 1990, reports were prepared on contaminant monitoring programmes using marine organisms: quality assurance and good laboratory practice and on guidelines for observation of meteorological parameters for marine pollution monitoring. Analytical techniques for organophosphorus pesticides and selected herbicides are currently being tested. A new catalogue of reference methods was produced by UNEP. These techniques are currently being used in international pollutant monitoring programmes throughout the world.

— instrument maintenance

The MESL maintenance engineer continued to install and service the analytical instruments employed by laboratories participating in UNEP's Mediterranean Action Plan (MEDPOL) and the West and Central Africa (WACAF) marine pollution monitoring programmes. During 1990, the engineer visited 14 laboratories in 8 countries (Benin, Cyprus, Ghana, Malta, Nigeria, Syrian Arab Republic, Tunisia and Yugoslavia).

Environment: fallout radioactivity

The programme on the monitoring of accidentally released radionuclides in environmental and food samples, which was initiated by the Agency in 1986 in response to the Chernobyl accident, was continued. Support was provided for 17 ongoing technical co-operation projects. A CRP on rapid instrumental and separation methods for the monitoring of radionuclides in food and environmental samples is continuing and supporting work on the development of methods is being carried out in the Agency's Laboratories at Seibersdorf. One analytical reference material was certified and 12 others are in various stages of preparation and intercomparison. These include nine materials related to Chernobyl that were prepared by Soviet laboratories.

Within the framework of the Agency's project to assess the radiological consequences in the USSR from the Chernobyl accident, a mission was undertaken by an international team of experts to study aspects relating to the nutritional status of persons living in the affected areas and non-radioactive environmental contamination. Samples of different kinds, including total diets, individual foodstuffs, human urine, blood, hair and milk (human and cow) were collected and analysed for non-radioactive components, such as toxic heavy metals and essential micronutrients. Many of these analyses were carried out in the Agency's Laboratories at Seibersdorf and a report is in preparation.

Assistance to Member States

In co-operation with the CEC and the National University of Mexico, investigations were conducted into the transport, fate and effects of agrochemicals in tropical coastal systems. This work included the use of radiolabelled pesticides in microcosm experiments and survey investigations into pesticide distributions within a lagoon system in Mexico. Results will be applicable to other Member States in Central America.

Assistance to Member States (cont.)

The ILMR continued to work with other agencies to develop and improve regional monitoring programmes to assist Member States to assess marine pollution and to provide the necessary technical support for their implementation. MESL staff are currently assisting UNEP and IOC in the co-ordination of a 31 country regional pollution assessment and control programme in the wider Caribbean region and missions were conducted to Colombia, Cuba, Jamaica, Mexico, St. Lucia, the USA and Venezuela in connection with this activity. Support was also given to programmes in the South Pacific, the Mediterranean (MESL is the regional analytical centre for the UNEP Mediterranean Action Plan), West and Central Africa and the Gulf countries. MESL was appointed as one of the two international analytical centres for the International Mussel Watch, which will evaluate the global distribution of pesticide residues in the marine environment.

Training

Seven fellows from seven Member States received training at the Agency's Laboratories at Seibersdorf during 1990.

Individual and group training courses were organized at MESL for the analysis of organochlorine compounds, organophosphorus pesticides, petroleum hydrocarbons, trace metals, organotins and methylmercury in marine environmental samples. Eighteen trainees were received from eight countries (Costa Rica, Egypt, Mexico, Morocco, Sweden, Syrian Arab Republic, Tunisia and Yugoslavia).

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1984	Human daily dietary intakes of nutritionally important trace elements as measured by nuclear and other techniques	1990	14
1985	Nuclear techniques for toxic elements in foodstuffs (RCA)	1990	11
1987	Use of nuclear and nuclear related techniques in the study of environmental pollution associated with solid wastes	1992	22
1988	Applications of stable tracers in human nutrition research	1992	15
1988	Rapid instrumental and separation methods for monitoring radionuclides in food and environmental samples	1992	12

CRPs established in the current year

Subject	No. of years	Participating institutions
Assessment of environmental exposure to mercury in selected human populations as studied by nuclear and other techniques	4	7
Isotope aided studies of the bioavailability of iron and zinc from human diets	4	5

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on determination of radionuclides in food and environmental samples	Germany	21	5 weeks
Regional course on radiochemical measurements in food and environmental samples	Yugoslavia	8	2 weeks

Industry and earth sciences

Industrial applications

General

Activities have focused on the assessment of the status and trends in the main areas of industrial applications. Manpower development, dissemination of information and technology transfer were major objectives. The increasing role of nuclear and nuclear related techniques in environmental conservation was emphasized.

Applications in the mineral industry

Exploitation of mineral resources has been a very important activity in the economic development of many Member States. Nuclear techniques have played a crucial role in this field. A publications issued in 1990 (IAEA-TECDOC-578) reviews the technical and economic benefits for the mineral industry in advanced countries achieved by the applications of nuclear techniques and nucleonic control systems. The advantages include rapidity, high specificity, adaptability to multiparameter analysis and control, relative simplicity and in some cases the possibility of application in hot, dusty and aggressive environments where no other instruments or methods can be used. The TECDOC evaluates the role and scope for these technologies in the mineral industry in developing Member States.

Environmental pollutants in coal and coke

Environmental pollution resulting from the burning of coal and coke has reached serious proportions in many parts of the world. Notwithstanding, the use of coal as an energy source is expected to increase considerably, particularly in developing countries. In this connection, a CRP on the development and evaluation of nuclear techniques for the on-line and bulk analysis and evaluation of potential environmental pollutants in coal and coke was initiated. Significant progress was reported at the first research co-ordination meeting in Indonesia, where the participants discussed the ecological problems resulting from the use of coal and established that pulverization and washing is probably the most useful measure for achieving a significant removal of pollutants from coal and coke used in electricity producing plants.

Environmental applications

Damage to the environment is becoming a major concern: pollution of air with SO_2 and NO_x, heavy metal and nitrate pollution of soil and water and levels of ecologically important compounds such as CO_2 and chlorofluorohydrocarbons. Nuclear and nuclear related techniques are playing an important role in the evaluation of environmental pollutants and in obtaining a deeper insight into the problems of environmental conservation. These aspects were discussed at a consultants meeting held in Poland. Nuclear techniques offer many advantages and can be used for in situ measurements, non-destructive analysis and multielement analysis with enhanced sensitivity.

Radiation processing

A CRP on electron beam purification of flue gases was continued. Promotion of this technology was carried out through the organization of national seminars in China, Mexico and the Philippines. With technical assistance from the Agency, a large scale demonstration facility is being installed in Poland.

A CRP on the radiation treatment of sewage sludge for safe disposal and reutilization was terminated with the final research co-ordination meeting which demonstrated the advantages of radiation technology and provided a database

Radiation processing (cont.)

on the technoeconomic factors useful for industrial feasibility studies. The proceedings of the meeting will be published as an IAEA-TECDOC in 1991.

Symposium

A symposium on nuclear techniques in the exploration and exploitation of energy and mineral resources was organized at Agency Headquarters in June. The symposium reviewed the latest concepts and developments in nuclear techniques applied to the exploration and exploitation of mineral resources and fostered an exchange of information on technology transfer to developing Member States. The symposium was attended by 68 participants representing 28 Member States. A total of 50 papers were presented, dealing with nucleonic control systems and on-stream analysers in the coal industry, on-line nuclear and nuclear related techniques in the mineral industry, nuclear borehole logging, instrumentation, data processing and interpretation, tracer techniques, radiometric methods and nuclear activation analysis. In addition, there was a panel discussion on the trends and future perspectives in nuclear and nuclear related techniques in the mineral industry. The proceedings are scheduled to be published in early 1991.

Non-destructive testing (NDT)

To assess the possibilities of introducing modern NDT methods into practice in developing countries and to define future activities, a consultants meeting on real time non-destructive monitoring of wear and corrosion using the thin layer activation technique (TLA) was held in May. It was concluded that this technique is one of the most effective methods of monitoring materials in their operating environments, and the benefits from TLA application in industry significantly exceed the costs. A new CRP on nuclear methods in the monitoring of wear and corrosion in industry was approved.

Transfer of NDT technology is provided through regional and national training courses, seminars, workshops and technical assistance projects. The Agency's activities are fully harmonized with the draft International Standard ISO/DIS 9712.

Material characterization

A regional (Asia–Pacific) workshop on characterization methods for new materials was held in China. Ceramics and high temperature superconductors have been identified as high priority R&D areas and X ray, neutron diffraction and scattering techniques as well as conventional methods can be used in their investigation. It was recognized that more extensive co-operation is needed in this field.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1984	Radiation treatment of sewage sludge for safe reutilization	1990	9
1985	Nuclear borehole logging techniques for the determination of rock characteristics	1991	10
1988	Radiation processing of combustion flue gases	1992	8
1988	Radiation processing technology applications in bioengineering	1992	9
1988	Development of diagnostic reagents for communicable diseases using radiation processing techniques	1991	6
1989	Nuclear techniques in the exploration and exploitation of coal: on-line and bulk analysis and evaluation of potential environmental pollutants in coal and coke	1992	8

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on the use of tracer technology in industry	Pakistan	13	3 weeks
Regional course on industrial radiation sterilization, quality control and sterility assurance (RCA)	Thailand	15	2 weeks
Regional course on industrial radiation sterilization — quality control and compatibility of materials (RCA)	India	15	2 weeks
Regional executive management seminar on industrial radiation curing technology (RCA)	Indonesia	12	2 weeks
Regional course on radiation cross-linking technology (RCA)	China	13	2 weeks
National course on industrial radiation sterilization	Philippines	23	1 week
National course on industrial radiation sterilization	Turkey	25	1 week
National course on radiation vulcanization of natural rubber latex	Thailand	26	1 week
National course on radiation cross-linking technology applications	China	32	2 weeks
Seminar on radiation processing of flue gases	China, Philippines, Mexico	25–30 (each)	2 days
Seminar on radiation treatment of sewage sludge	China, Thailand, Indonesia	30–40 (each)	2 days
National course on radiography, level 3 (RAS)	Philippines	13	3 weeks
National course on ultrasonics, level 3 (RAS)	Indonesia	21	3 weeks
National course on eddy currents, level 2 (RAS)	Pakistan	11	3 weeks
National course on surface methods, level 2 (RAS)	Malaysia	18	3 weeks
Regional course on inspection of liquid petroleum gas cylinders (RLA)	Peru	13	1 week
Regional course on ultrasonic and radiographic testing in casting inspection (RLA)	Mexico	15	1 week
National course on eddy currents, level 3 (tubes) (RLA)	Peru	14	2 weeks
Regional course on diagnosis of rotating equipment (RLA)	Jamaica	14	2 weeks
Regional course on computers in radiographic inspection (RLA)	Mexico	14	5 days

Publications

Series and No.	Title
Technical Reports Series No. 316	Guidebook on radioisotope tracers in industry
IAEA-TECDOC-551	Radiation damage to organic materials in nuclear reactors and radiation environments
IAEA-TECDOC-578	Technology transfer of nuclear techniques and nucleonic control systems in the mineral industry

INDUSTRY AND EARTH SCIENCES

Development of water and mineral resources

Isotope hydrology

The Agency supported 44 technical co-operation projects in 34 Member States and regional projects in Africa, the Middle East and Latin America (ARCAL XIII, financially supported by Germany), and four CRPs.

Groundwater studies in arid and semi-arid zones

Investigations continued or were initiated in numerous arid and semi-arid zones to assess groundwater origin, recharge and dynamics. The countries where studies were carried out are Cameroon, Chile (Atacama Desert), Egypt (Aswan Dam region), Iraq, Jordan, Mongolia (Gobi Desert), Morocco (Errachidia, Kheng el Hamman), Niger, Peru (Lima aquifer, Sechura Desert), Senegal, Sudan, Syrian Arab Republic, United Arab Emirates and Yemen. As expected, in unconfined aquifers the direct recharge from precipitation is usually negligible and the evaporation losses from the water table often exceed it. In Niger, an empirical curve showing the evaporative losses as a function of the water table depth has been determined for sand dunes on the basis of the stable isotope composition of water in the unsaturated zone. In other arid areas the main source of recharge is surface water, as has been shown in Chile, Egypt, Peru and Sudan.

Most of the results obtained in Africa were presented at a regional seminar which was held in Vienna in October.

Groundwater investigations in tropical countries

Investigations to evaluate the different sources of recharge (precipitation versus surface water) and the dynamics of groundwater were initiated in Bolivia (Cochabamba valley), Colombia (San Andrés), Costa Rica, Ecuador (Rio Guayas), Guatemala, Haiti, Nicaragua, Viet Nam and Zimbabwe. In most cases recharge is taking place actively and groundwater is usually recent, as shown by the isotopic composition, but pockets of 'old' water may occur (Haiti). Isotope aided studies of water routing in the Amazon Basin continued in the framework of the Amazon project. Downward movement of soil water in the region was studied using isotope tracers (tritium, deuterium). A regional network of stations was set up to study isotope patterns in precipitation over the region.

Groundwater salinization

In Portugal (Algarve) and Haiti (Plain de l'Arbre) it has been shown on the basis of the stable isotope–salt content correlation that the origin of groundwater salinization is mainly sea water encroachment and that only in eastern Algarve may salt dissolution play a role. Other field studies deal with the aquifers in the La Plata (Argentina) and Monterrey (Mexico) areas.

Groundwater contamination

During two missions in the area of Chernobyl, groundwater, surface water and sediment samples were collected in order to study radioactive pollutant movement and deposition, and an appraisal was made of analytical results obtained so far by Soviet institutions concerning water contamination.

In the aquifers adjacent to Lake Valencia (Venezuela) the possibility of contamination by lake water is being assessed.

Geothermal studies

A CRP for Latin America on the application of isotope and geochemical techniques in geothermal exploration (financially supported by Italy) was concluded, with the last research co-ordination meeting held in San José, Costa Rica. In the programme, 28 geothermal areas were studied. A number of these showed promising characteristics for high enthalpy fluid production and electric power

Geothermal studies (cont.)

generation. A similar CRP was initiated for Africa, Asia and the Middle East. Studies have continued within the framework of a contract with the Centro Informazioni Studi e Esperienze (CISE), Milan, Italy. These have elucidated the mechanisms of release from the host rock of the U–Th family isotopes in a geothermal reservoir.

Radioactive isotopes were used to identify patterns of fluid reinjection in the geothermal fields of Ahuachapan (El Salvador) and Miravalles (Costa Rica).

Surface water and sedimentology

A study of dispersion in the Magdalena River (Colombia) was completed, with results showing the possibility and the limitations of using tritium as a tracer in large rivers for discharge measurements. The preferential patterns of lake water discharge into groundwater were identified for Lake Amatitlan, Guatemala, using environmental isotopes. Sediment transport experiments with isotope tracers were carried out in Bangladesh, Cuba, Malaysia and Mali, and the preparatory work has been completed for similar investigations in Shanghai harbour (China) and in Viet Nam.

Precipitation and atmospheric studies

Ten new stations were incorporated in the global network for isotopes in precipitation. The statistical elaboration of the database continued, leading to the identification and elimination of a number of doubtful results. Recent tritium trends in precipitation have shown the occurrence of contamination sources in some regions.

Work has continued in collaboration with the Institut für Atmosphärische Radioaktivität (Freiburg, Germany) to measure the ^{85}Kr concentration in the air in Vienna.

Isotopic standards and intercalibration

The Isotope Hydrology Laboratory provided laboratories in Member States with 320 samples for stable isotope measurement calibration and intercomparison. The results of a tritium intercomparison exercise among ten laboratories was reported at a meeting in Yugoslavia. Five samples for ^{14}C measurement intercalibration were distributed to about 140 laboratories. The results will be discussed at a consultants meeting in early 1991.

Assistance to Member State laboratories

The following facilities have been installed:

- Hydrochemical laboratories to complement isotope measurements in water in Guatemala and Haiti;
- Gas chromatography laboratories to complement isotope measurements in geothermal gases in Guatemala and Venezuela;
- Nuclear sedimentology laboratory in Morocco;
- Isotope tracer laboratory for hydrological investigations in Ecuador;
- Benzene synthesis lines for ^{14}C determinations in Turkey and Uruguay;
- Enrichment and tritium counting systems in Sudan and Turkey;
- Hydrogen preparation line for isotope analysis in Malaysia.

In addition, assistance for equipment maintenance and upgrading was given to institutes in Chile, Colombia, Indonesia and Turkey.

Co-operation with other United Nations organizations

As a result of the continued co-operation of the Agency with UNESCO in the field of water resources, a report on the use of nuclear techniques in sediment transport and sedimentation problems, prepared under the technical supervision of the Agency, was published by UNESCO. Co-operation also continued with WMO in the collection of monthly precipitation samples for isotope determinations.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1985	Application of isotope and geochemical techniques in geothermal exploration in Latin America	1990	9
1987	Nuclear techniques in the study of pollutant transport in the environment: interaction of solute with geological media (methodological aspects)	1992	13

CRPs established in the current year

Subject	No. of years	Participating institutions
Application of isotope and geochemical techniques in geothermal exploration in Africa, Asia and the Pacific, and the Middle East	3	8
Isotope variation of carbon dioxide and other trace gases in the atmosphere	3	10
Mathematical models for quantitative evaluation of isotope data in hydrology	3	8

Training courses and seminars held

Course name	Location	No. of participants	Duration
Advanced regional course on the use of environmental isotopes in hydrology	Chile	24	3 weeks
Regional course on isotope techniques in hydrology	India	15	3 weeks
Regional seminar on isotope techniques in hydrology for developing countries in Africa	Headquarters	38	1 week

Publications

Series and No.	Title
Technical Reports Series No. 311	Environmental isotope data No.9: world survey of isotope concentration in precipitation (1984–1987)

Physical and chemical sciences

Nuclear measurements and instrumentation

Computer software

The development of computer software for nuclear applications has continued. A new software package for use in gamma ray spectrum analysis, activity calculations and neutron activation analysis was designed and produced. The system is available to Member States free of charge.

Stack monitor

A stack monitor was designed and constructed for the Portuguese research reactor to help ensure safe operation and environmental protection. This is the second stack monitor of this type. All technical documentation is available to permit construction at any research reactor site.

Monitoring system

An early warning environmental radiation monitoring system in the Syrian Arab Republic is in operation after modification of its software at the Agency's Laboratories, Seibersdorf and training of relevant staff in the field. A similar system in Turkey was successfully tested in a trial connection through public communication media between the control computer and a remote data exchange station.

Sample analysis

Total reflection X ray fluorescence methods were introduced in the Agency's Laboratories to measure samples from the Chernobyl area and to conduct relevant training activities.

Instrumentation

The Instrumentation Unit was involved in direct support to Member States in establishing the necessary technical infrastructure for the repair and maintenance of nuclear instrumentation. A software package was developed and distributed for the management and service of nuclear instrumentation in the African region. Twenty-five fellowship trainees and scientific visitors from 18 developing countries received intensive training totalling 70 person-months.

Nuclear data centre networks and services

The Agency continued to co-ordinate worldwide networks of nuclear and atomic data centres concerned with:

- nuclear reaction data;
- nuclear structure and decay data;
- atomic and molecular data.

The co-ordination is carried out through annual meetings of the networks. Work is under way on the development of complementary on-line access services.

During 1990, several new evaluated nuclear data files became available (BROND from the USSR, ENDF/B-6 from the USA, JEF-1 from the OECD/NEA and JENDL-3 from Japan). The Agency fulfilled more than 720 requests from 68 Member States for experimental and evaluated data, related data processing computer codes and nuclear data publications. Several specialized nuclear and atomic data libraries were produced, including IRDF-90 (an international reference database for reactor neutron dosimetry by the multiple foil activation method) and a database for neutral hydrogen beam penetration into fusion plasmas. The CINDA database, an index to the literature and computer files on microscopic neutron data, was published as a six volume reference handbook covering the period 1935–1987, to which annual supplements are planned.

Technology transfer

Continued support (expert advice and computer equipment) was given to the development of national nuclear data centres in China and Indonesia. Thirteen nuclear laboratories in individual developing countries, mostly African, were given continued support for the development of nuclear analytical facilities in terms of equipment, expert assistance and manpower training.

Data assessment and research co-ordination

Expert groups were convened to review the status of and assess the requirements for atomic and molecular data needed in fusion plasma research, nuclear data at energies above 20 MeV for nuclear waste transmutation by medium energy proton accelerators, space and medical research and data related to neutron multiplication in conceptual fusion reactors. Consultants reviewed recent developments and the requirements for further research regarding nuclear data for fusion technology and for predictions of neutron emission in the fission process. Work continued on the development of nuclear and atomic databases appropriate to the design of fusion reactors.

Neutron nuclear data for structural materials

A CRP on assessing the reliability of the calculational methods used for the evaluation of neutron nuclear data for structural materials of fast breeders and fusion reactors was completed. The programme emphasized the considerable progress that had been made, most notably in the improvement of global optical models using dispersion relations and in the understanding of the significant role of collective excitations in fast neutron induced reactions.

INDC and IFRC

The International Nuclear Data Committee (INDC), at its 18th meeting in October, and the International Fusion Research Council (IFRC) Subcommittee on Atomic and Molecular Data for Fusion, at its 6th meeting in September, devoted their main deliberations to the changes in nuclear and atomic data requirements over the medium term period 1993-1998. The emphasis during this period will be on improved data for: fusion reactor development (e.g. ITER), reactor decommissioning, feasibility studies of minor actinide transmutation and incineration, advanced reactor design and safety, and intermediate energy applications.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1986	Nuclear data needed for neutron therapy	1991	9
1987	Measurement and analysis of 14 MeV neutron induced double differential neutron emission cross-sections needed for fission and fusion reactor technology	1992	7
1989	Atomic and molecular data for fusion edge plasmas	1992	11
1989	Atomic and molecular data for radiotherapy	1993	14
1989	Activation cross-sections for the generation of long lived radionuclides	1994	8

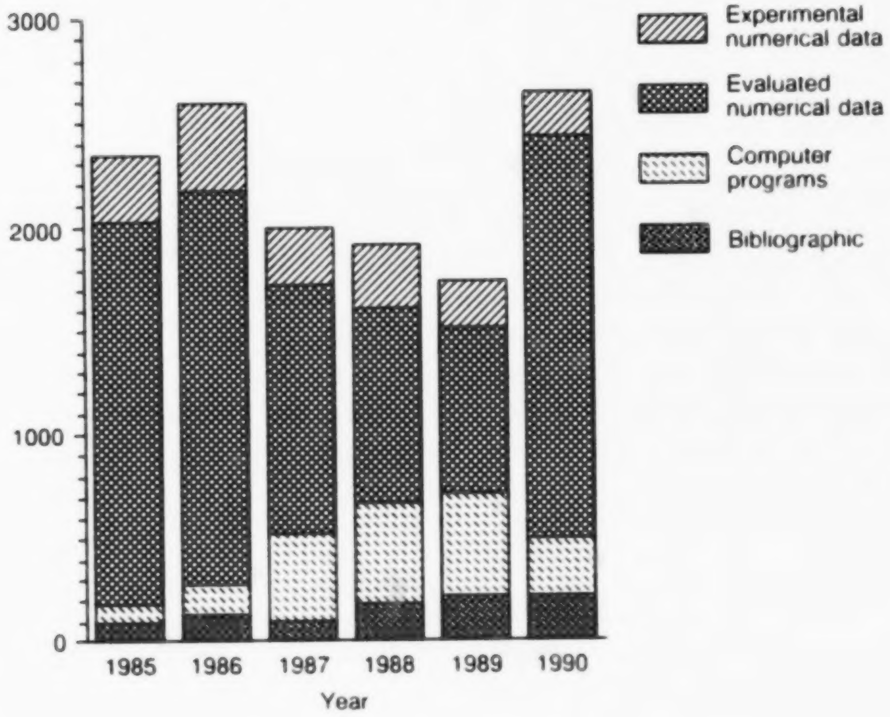
CRPs established in the current year

Subject	No. of years	Participating institutions
Plasma interaction induced erosion of fusion reactor materials	3	10

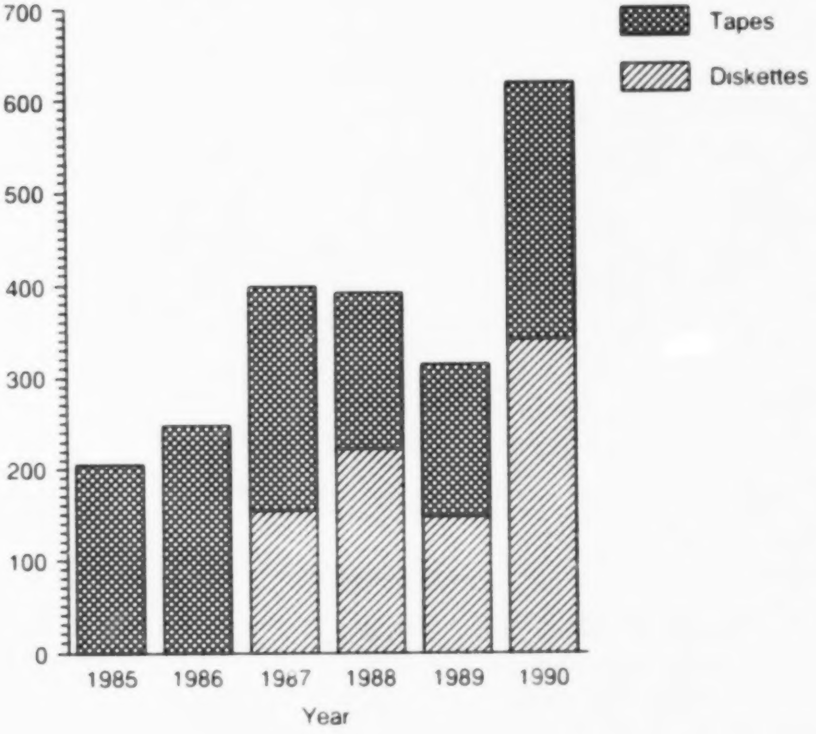
Publications

Series and No.	Title
	CINDA 90 (1988-1990)
	CINDA A (1937-1987)
IAEA-TECDOC-572	Nuclear data for radiation damage assessment and related safety aspects 1989
NEANDC-259 'U'	Evaluation of cross-sections for important neutron dosimetry reactions
INDC(NDS)-218/GZ	Cross-sections of monitor reactions for radioisotope production
INDC(NDS)-232/L	Activation cross-sections for the generation of long lived radionuclides of importance in fusion reactor technology
INDC(NDS)-233/L	Measurement, calculation and evaluation of photon production cross-sections
INDC(NDS)-234/L	Measurements and analysis of double differential neutron emission spectra in (p, n) and (α, n) reactions
INDC(NDS)-235/L	The INDC/NEANDC joint discrepancy file 1990
INDC(NDS)-236/M5	Atomic and molecular data for metallic impurities in fusion plasmas
INDC(NDS)-237/M6	Thermal response of plasma facing materials and components
INDC(NDS)-239/LNA	Report of the Nuclear Data Section to the International Nuclear Data Committee — March 1989 - June 1990
INDC(NDS)-240/L	Measurement and analysis of 14 MeV neutron induced double differential neutron emission cross-sections
INDC(NDS)-241/L+F	First results of FENDL-1 testing and start of FENDL-2
INDC(NDS)-243/M7	Ninth meeting of atomic and molecular data centres and ALADDIN network
IAEA-NDS reports	Description of various computerized data files available from the Nuclear Data Section
INDC country coded reports	Technical reports on nuclear data related research in Member States

DISTRIBUTION OF NUCLEAR DATA TO MEMBER STATES



MAGNETIC TAPES AND DISKETTES WITH NUCLEAR DATA SENT TO MEMBER STATES



Training courses and seminars held

Course name	Location	No. of participants	Duration
Advanced interregional course on nuclear electronics	USA	21	12 weeks
Advanced interregional course on interfacing in nuclear experiments	Thailand	19	8 weeks
Advanced interregional course on experimental nuclear spectroscopy	Greece	24	4 weeks
Regional course on power supplies for nuclear instruments	Guatemala	11	3 weeks
Regional course on nuclear electronics (maintenance oriented)	Turkey	18	6 weeks
Regional course on nuclear instrumentation maintenance	Morocco	20	6 weeks
Regional course on maintenance of gamma cameras	Colombia	10	4 weeks
Regional course on maintenance of industrial nuclear instrumentation	Mexico	12	3 weeks
Regional course on application of programmable logic controllers	Argentina	9	2 weeks
National course on the use of personal computers in nuclear laboratories	Indonesia	26	3 weeks
National workshop on nuclear instrumentation maintenance	Jordan	22	6 weeks
Third group fellowship training in nuclear spectroscopy instrumentation maintenance	IAEA Seibersdorf	8	13 weeks
Fourth group fellowship training in nuclear spectroscopy instrumentation maintenance	IAEA Seibersforf	8	13 weeks

International Centre for Theoretical Physics

(Jointly operated by the IAEA and UNESCO)

Fields of research and training

The main fields of research and training for research at the Centre in 1990 were: fundamental physics (high energy and particle physics, cosmology and astrophysics); condensed matter physics (condensed matter physics and related atomic and molecular physics, materials science, surfaces and interfaces, liquids and statistical mechanics); mathematics (applicable mathematics, systems analysis, mathematical ecology, mathematics of development, mathematics in industry, differential geometry, topology, differential equations, analysis and mathematical physics); physics and energy (nuclear physics, plasma physics, solar energy and wind energy); physics and the environment (geophysics, soil physics, seismology, climatology and meteorology, physics of the oceans, physics of desertification, physics of the atmosphere, troposphere, magnetosphere and aeronomy and remote sensing); physics of the living state (neurophysics, biophysics and medical physics); applied physics and high technology (physics in industry, microprocessors, communications, instrumentation, synchrotron radiation, non-destructive evaluation, optical fibres, lasers and computational physics); and the physics of space (microgravity, artificial satellites) and science, high technology and development.

Some 4400 scientists took part in the activities of the Centre and in the programme for training at Italian laboratories, staying for a total of almost 5000 person-months. Sixty-five per cent of them were from developing countries, accounting for 85% of the total person-months. Associate Members from developing countries numbered 432, and there were 412 federated institutes in developing countries.

Funding

The implementation of the programme was made possible through the generous financial contribution of the Italian Government of $14 342 630. Of this, $7 171 315 was the ordinary contribution, while $7 171 315 came from the Direzione Generale per la Cooperazione allo Sviluppo of the Ministry for Foreign Affairs, Rome, in support of some activities at the ICTP itself, of the training programme in Italian laboratories and of external activities. The contributions of the IAEA and UNESCO amounted to $1 257 000 and $339 700, respectively.

The Centre also acknowledges with gratitude contributions from SAREC (Sweden), $212 072; UNIDO, $90 000; the Kuwait Arab Fund, $60 000; Kuwait Foundation for the Advancement of Science, $50 000; UNESCO — Chair, $43 000; the Government of Japan, $39 120; the Royal Society (UK), $29 502; the University of Kuwait, $25 000; the Instituto de Matemática Pura e Aplicada (Brazil), $16 000; the Union des assurances de Paris (France), $5000; and the CANDU Owners Group of Canada, $1724.

Fundamental physics

Course name	Total No. of participants	Participants from developing countries	Duration
Spring school on string theory and quantum gravity and workshop on string theory	155	44	2 weeks
Trieste conference on topological methods in quantum field theory	147	28	5 days
Summer school in high energy physics and cosmology	275	185	6 weeks

Mathematics

Course name	Total No. of participants	Participants from developing countries	Duration
Workshop on composite media and homogenization theory	97	32	2 weeks
Second college on variational problems in analysis	78	45	3 weeks
Workshop on group theory from a geometrical viewpoint	105	52	2 weeks
School on qualitative aspects and application of non-linear evolution equations	200	87	4 weeks
Third autumn course on mathematical ecology	149	33	3 weeks

Condensed matter, atomic and molecular physics

Course name	Total No. of participants	Participants from developing countries	Duration
Winter college on high resolution spectroscopy	69	49	4 weeks
Experimental workshop on high temperature superconductors and related materials (basic activities)	90	70	3 weeks
Spring college on condensed matter: physics of low dimensional semiconductor structures	121	81	2 months
Miniworkshop on quantum chaos	92	36	5 weeks
Miniworkshop on strongly correlated electron systems	95	31	6 weeks
Research workshop on condensed matter, atomic and molecular physics	408	298	3 months
Symposium on frontiers in condensed matter physics	49	7	3 days
Working party on electrochemistry–condensed matter aspects	69	35	2 weeks
Experimental workshop on high temperature superconductors and related materials (advanced activities)	66	31	3 weeks

Physics and energy

Course name	Total No. of participants	Participants from developing countries	Duration
Workshop on reactor physics calculations for applications in nuclear technology	80	58	5 weeks

Physics and the environment

Course name	Total No. of participants	Participants from developing countries	Duration
College on atmospheric boundary layer physics — I: Modelling of atmospheric flow fields	93	66	10 days
College on atmospheric boundary layer physics — II: Air pollution modelling for environmental impact assessment	98	69	2 weeks
Workshop on atmospheric limited area modelling	76	32	3 weeks
Workshop on earthquake sources and regional lithospheric structures from seismic wave data	74	21	2 weeks

Physics of the living state

Course name	Total No. of participants	Participants from developing countries	Duration
Third international conference on applications of physics in medicine and biology — medical diagnostic imaging (Giorgio Alberi Memorial)	167	29	4 days
College on medical physics	101	38	3 weeks
Neurophysics college on neural correlates of behaviour, development, plasticity and memory	94	31	3 weeks

Applied physics and high technology

Course name	Total No. of participants	Participants from developing countries	Duration
Training college on physics and characterization of lasers and optical fibres	96	55	4 weeks
First ICFA school on beam dynamics and engineering of synchrotron light sources	59	22	2 weeks
College on recent developments and applications in mathematics and computer science	87	71	4 weeks
College on the design of real time control systems	79	48	4 weeks
First international school on computer network analysis and management	64	5	2 weeks

Anniversary Adriatico Research Conferences

In 1990, the Anniversary Adriatico Research Conferences series included short meetings on: Fourier optics and holography; quantum chaos; quantum fluctuations in mesoscopic and macroscopic systems; the physics of strongly correlated systems; and defects in hexagonal close packed crystals. One hundred and one scientists from developing countries, out of a total of 278, took part.

Training at Italian laboratories

One hundred and twenty scientists from developing countries carried out research at Italian academic and industrial laboratories under a programme which started in 1982 with the financial support of the Italian Direzione Generale per la Cooperazione allo Sviluppo.

External activities

In the fields of physics and pure and applied mathematics, the Centre sponsored 43 courses, workshops and symposia in 22 countries. Ten Affiliated Centres were established in ten countries and two Networks were created involving seven countries. These programmes were financed by the Direzione Generale per la Cooperazione allo Sviluppo.

Meetings hosted by the Centre

The Centre hosted 22 meetings. Six of them were organized by the International Centre for Science, while other major organizing institutions were the Third World Academy of Sciences, the Italian National Institute of Nuclear Physics, the International Centre for Genetic Engineering and Biotechnology and the International Union of Pure and Applied Physics.

Other conferences

A two day conference on scientific co-operation with Eastern Europe was held in March in Trieste at which the present state of, and future perspectives on, science and technology in Eastern Europe were discussed. There were 138 participants, out of which 93 were from developing countries. Another two day conference was held in November on co-operation in science, high technology and the environment between north and south Mediterranean countries. Sixty-eight scientists attended, out of which 25 were from developing countries.

Books and equipment donation programme

During the period October 1989 to September 1990, the Centre was able to distribute 37 387 journals, 8400 proceedings, 5099 books and 7409 publications to 1500 institutions in 100 developing countries. Besides the donations directly distributed by the Centre, a large number of donations of complete sets of back issues of journals were shipped directly by the donors to institutions in developing countries.

Equipment from CERN was sent to institutions in the following countries: China, Colombia, the Islamic Republic of Iran, Jordan and Pakistan.

Awards

The 1990 Dirac Medals of the ICTP were awarded to Ludwig Dmitrievich Fadeev, from the Steklov Mathematical Institute, Leningrad, USSR, for research in the area of quantum field theory and mathematical physics, and Sidney R. Coleman, from Harvard University, Cambridge, Massachusetts, USA, for his contributions to quantum field theory and particle physics.

The 1990 ICTP Prize in honour of C.V. Raman was awarded to José Luis Morán-López, a solid state physicist from the Universidad Autónoma de San Luis Potosí, Mexico, for his contributions to surface magnetism.

Preprints and internal reports

In 1990, 480 preprints and internal reports were issued.

Publications

Series and No.	Title
IAEA-TECDOC-575	International Centre for Theoretical Physics Trieste: scientific activities in 1989

Utilization of research reactors and particle accelerators

Ageing of research reactors

A refined draft report dealing with components and systems susceptible to ageing was prepared. A report is expected to be published in 1991 to assist reactor operators in system modifications and replacement to assure continued safe operation of research reactors.

Fuel burnup

A report on the determination of research reactor fuel burnup was drafted and is expected to be published in 1991. The report will assist operators to calculate and measure burnup so as to more economically use reactor fuels, increase safety and optimize reactor performance.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Analysis of research reactor cores for use of low enriched uranium fuels	1992	6

CRPs established in the current year

Subject	No. of years	Participating institutions
Application of personal computers to enhance the operation and management of research reactors	3	8

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on research reactor safety principles (RCA)	India	11	2 weeks
Regional course on technology and use of small research reactors (RCA)	China	15	1 week
Regional course for research reactor operators (ARCAL)	Brazil	13	3 weeks
Regional course on burnup determination of research reactor fuels (ARCAL)	Mexico	12	2 weeks
Interregional course on research reactor core conversion to low enriched uranium fuels	Australia	18	4 weeks
Regional course on introduction to safety calculations for research reactors (ARCAL)	Argentina	12	3 weeks

Publications

Series and No.	Title
Reference Data Series No. 3	Nuclear research reactors in the world
Technical Directories	Directory of nuclear research reactors

Chemistry

Production of radioisotopes and radiopharmaceuticals

A new CRP on the evaluation of bulk reagents for the production of $^{99}\text{Tc}^{\text{m}}$ radiopharmaceutical kits was initiated. The main purpose is to develop reliable and reproducible as well as economical methods for the synthesis of bulk ligands and protocols of kit formulation.

Laboratory manual

Work was started on a laboratory manual on the preparation of kits for $^{99}\text{Tc}^{\text{m}}$ radiopharmaceuticals. The manual is intended primarily to help professionals from developing countries in their efforts to start or strengthen their radiopharmaceutical programmes. The manual details procedures for the preparation of kits, including quality control protocols, and also discusses legal and regulatory questions. It will appear as an IAEA-TECDOC.

Labelling of monoclonal antibodies

A consultants meeting discussed the potential of using radiolabelled monoclonal antibodies in immunoscintigraphy and a CRP on labelling, quality control and clinical evaluation in this field was initiated. As the model antibody, an anti-carcinoembryonic antigen for colorectal tumours was selected for the initiation of this CRP and $^{99}\text{Tc}^{\text{m}}$ will be used as the labelling radionuclide.

Radiotracer applications

Significant progress was reported, at a research co-ordination meeting in Poland, in the CRP on the applications of radiotracers in the development of new separation techniques for trace element analysis by nuclear methods, with special emphasis on environmental research. The developments reported included a new separation method — electrostatic pseudo-liquid membrane (ESPLIM) — for *f* element recovery, reactor neutron activation analysis and isotope dilution analysis for estimation of trace levels of As and Sb in dust particles, a novel application of solvent extraction and co-precipitation for preseparation–preconcentration of seven first transition elements and evaluation of mixed ligand complexes to enhance sensitivity and selectivity in the determination of hydrolysable toxic and essential elements.

Analytical quality control services

The Agency's Laboratory at Seibersdorf continued to support and assist laboratories in Member States involved in the analysis of nuclear, environmental and biological materials.

Intercomparison runs

In 1990, 19 intercomparison runs with different materials, some of them with elevated levels of radioactivity resulting from the Chernobyl accident, were organized. Five intercomparison runs (IAEA-155 whey powder for trace elements, IAEA-156 clover for radionuclides and IAEA-312 soil, IAEA-313, 314 stream sediment for radium, uranium and thorium) were completed.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Nuclear analytical techniques for trace element analysis in agricultural products and food	1992	11
1989	Radiotracers in the development of new separation techniques for trace element analysis by nuclear methods, with special emphasis on environmental research	1992	10

CRPs established in the current year

Subject	No. of years	Participating institutions
Nuclear analytical techniques in atmospheric and water pollution studies	3	12
Labelling, quality control and clinical evaluation of monoclonal antibodies for scintigraphy	3	13
Evaluation of use of bulk reagents for production of ^{99}Tc^{m} radiopharmaceutical kits	3	10

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional workshop on fabrication of NDT test pieces	Japan	12	13 days
Regional workshop on radiation protection for radiographers (RLA)	Argentina	17	5 days
Regional workshop on applications of neutron activation analysis in environmental studies	Colombia	16	4 weeks
Regional course on nuclear analytical techniques in fossil energy resources	Mexico	12	4 weeks
Regional course on the analysis of environmental samples by X ray fluorescence	Paraguay	12	3 weeks
Regional workshop on analytical quality assurance	Argentina	10	2 weeks
Regional course on the preparation and control of radiopharmaceuticals	China	18	5 weeks

Publications

Series and No.	Title
IAEA-TECDOC-537	Prompt gamma neutron activation analysis in borehole logging and industrial process control
IAEA-TECDOC-564	Practical aspects of operating a neutron activation analysis laboratory

Radiation protection

Basic principles and criteria

Basic criteria

The Basic Safety Standards (BSS) for Radiation Protection (IAEA Safety Series No. 9, first published in 1962 and issued in revised form in 1982 jointly by the IAEA, ILO, OECD/NEA and WHO) are based on the recommendations of the International Commission on Radiological Protection (ICRP). A recently completed revision by ICRP of its basic recommendations on radiation protection has necessitated a revision of the BSS. To facilitate this task, an interagency committee on radiation safety was formed, consisting of FAO, IAEA, OECD/NEA, the Pan American Health Organization (PAHO) and WHO, with the co-operation of the CEC.

Symposium

The proceedings of an international symposium on radiation protection infrastructure, held in Munich, Germany, and attended by experts from 45 Member States, were published. The symposium examined radiation protection regulations, notification, registration, licensing, inspection and control programmes, national infrastructures and approaches which have proved to be effective, education and training, the role of professional associations, the contribution of radiation protection services such as personal dosimetry, international activities and other specific issues. It was concluded that many countries, in particular the least developed countries, still lack the necessary infrastructure for implementing a safety policy that is based on international recommendations.

Intervention in the event of an accident

In an accident the sources of exposure are, by definition, not under control and therefore the system of dose limitation recommended by the ICRP and incorporated in the BSS does not apply. However, the principles underlying the system of dose limitation can also form the basis for planning intervention in the event of an accident. The proper criteria for intervention must be derived during the planning for emergencies and re-evaluated and updated as the situation changes. In order to update guidance contained in IAEA Safety Series No. 72, a major revision was completed in 1990 setting down the principles for the protection of workers and of the public in the event of an accident and discussing application of the principles. This revised document will be published in 1991.

Regional co-operation on radiation safety

In addition to over 120 national projects, and regional and interregional training courses, four major regional projects were under way supplementing efforts carried out within national technical co-operation projects, all aimed at strengthening radiation safety capabilities in developing Member States. Regional projects involved co-operation between 14 Member States in the Asia and Pacific region (RCA), 14 in the Middle East, 17 in Africa and — with Panama participating — 15 in Latin America (ARCAL).

RAPAT

Since 1984, the Agency has undertaken Radiation Protection Advisory Team (RAPAT) missions to Member States requesting assistance in reviewing infrastructural needs and in defining a long term strategy for technical assistance and co-operation. Five requests were received in 1990, from Bolivia, the Libyan Arab Jamahiriya, Romania, Sri Lanka and Uruguay, bringing the total number of visits to Member States since 1984 to 51.

Personal monitoring services provided by the Agency in 1990[a]

TLD[b] readings	19 400
Fast neutron dosimeters	300
Extremity dosimeters	1 000
Area monitors	570
Whole body countings	1 024
Urine analyses (^{90}Sr, ^{239}Pu and ^{241}Pu)	936

[a] Measurements in support of the Chernobyl project are excluded.

[b] TLD: thermoluminescent dosimetry.

Personal dosimetry

Radiation protection service activities were enlarged in 1990. Following the agreement between the Agency and WHO, personal monitoring services previously provided by WHO to some least developed countries (approximately 9000 readings per year) were taken over by the Agency. Also, computer programs for whole body counting and extremity dosimetry were improved. For monitoring/assessment purposes under the Chernobyl project, 8000 French film dosimeters were distributed and about 10 000 whole body counts performed.

CRPs established in the current year

Subject	No. of years	Participating institutions
Radiation doses in diagnostic radiology and methods for reduction	2	15

Training courses and seminars held

Course name	Location	No. of participants	Duration
In-house training on radiation protection for new safeguards inspectors	Headquarters	—	4 days
National workshop on radiation protection for technologists	United Arab Emirates	14	2 weeks
Regional workshop on radiation protection and quality assurance in medicine	Kuwait	26	2 weeks
National workshop on radiation protection for technologists	Sierra Leone	16	3 days
National workshop on radiation protection for medical doctors	Nigeria	8	1 week
Seminars for general practitioners on health effects of ionizing radiation	USSR	1200	2 weeks
National workshop on radiation protection of patients and workers	Mongolia	16	2 weeks
Workshop on development of a national infrastructure for radiation safety	Viet Nam	21	3 weeks
Workshop on intercomparison of personnel dosimeters	Japan	14	5 days
Regional workshop on basic radiation protection and development of a national infrastructure for radiation safety	Nigeria	24	2 weeks
National workshop on radiation protection and quality assurance in diagnostic radiology	Viet Nam	34	2 weeks
Course on radiation sources and principles of radiation protection	Syrian Arab Republic	24	1 week
Interregional course on radiation protection and nuclear safety	Argentina	19	8 months
Regional course on development of infrastructures for ensuring radiation protection	Australia	16	4 weeks
Workshop on radiation protection	Guatemala	14	5 days
Workshop on intervention levels for food contamination	Argentina	7	5 days
National course on dose evaluation for overexposed persons	Guatemala,	12	2 weeks
	Costa Rica	10	2 weeks
National course on radiation protection in radiology	Guatemala,	27	5 days
	Costa Rica	15	5 days
Regional course on radiation protection in medical practice	Cuba	19	2 weeks
Regional course on radiation protection in radiodiagnosis	Ecuador	23	2 weeks
National course on safe transport of radioactive materials	Chile,	25	10 days
	Peru,	10	10 days
	Costa Rica	9	10 days
Workshop on implementation of conventions	Chile	9	5 days

Publications

Series and No.	Title
Proceedings Series	Radiation protection infrastructure
Safety Series No. 104	Extension of the principles of radiation protection to sources of potential exposure

Occupational radiation protection

Co-operation with international standards organizations

The International Commission on Radiation Units and Measurements (ICRU) and the International Commission on Radiological Protection (ICRP) are both in the process of changing guidance related to radiation protection. These changes would affect programmes in Member States. The Agency has been working with these organizations to provide: (a) feedback on the practical aspects of these changes, and (b) additional information necessary to make the guidance complete. For example, information obtained from a CRP on intercomparison for individual monitoring was provided to the ICRU working group, which resulted in changes to a draft report on operational quantities for external monitoring to make it more practical for use in Agency Member States.

Monitoring for internal contamination

Work continued on the preparation of three Safety Series publications covering: assessment of the occupational intake of radioactive materials; rapid monitoring of large groups of internally contaminated people; and direct methods for measuring radionuclides in man.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Intercomparison programme for individual monitoring	1993	25
1988	Compilation of anatomical, physiological and metabolic characteristics for a reference Asian man	1994	10

Publications

Series and No.	Title
Safety Series No. 101	Operational radiation protection: a guide to optimization
Safety Series No. 103	Provision of operational radiation protection services at nuclear power plants
Technical Reports Series No. 318	Compendium of neutron spectra and detector responses for radiation protection purposes

Environmental assessment and protection

International Chernobyl Project

In response to a request from the USSR, a major international study, 'The International Chernobyl Project', was initiated to understand more fully the radiological consequences in the USSR of the Chernobyl accident through an assessment of the health and environmental effects and an evaluation of the protective measures taken. The goals of the project, which is to be concluded early in 1991, were to: (a) verify the available data on environmental contamination and human exposure, though not to duplicate the efforts of the Soviet authorities, and (b) evaluate the adequacy of the measures taken and planned to protect the population. After an initial planning meeting, a ten member fact finding mission visited affected areas to identify problems and introduce the project to the public, while an international advisory committee developed a work plan. The five main tasks undertaken were a historical portrayal of events, environmental assessment of the existing contamination, radiation dose assessment, a study of the clinically observed health effects and, finally, an evaluation of the protective measures taken. In early 1991, the international advisory committee will meet to agree on a final comprehensive report of their scientific findings which will subsequently be published by the Agency.

Agency response to the concern over radon

In recognition of the global concern over the issue of radon, and in response to requests from 56 Member States, the Agency initiated, jointly with the CEC, a CRP on radon in the human environment. The International Agency for Research on Cancer (in Lyon, France) and WHO agreed to provide logistical support in all areas related to the assessment of the potential health effects. The objective of the CRP is to co-ordinate international research efforts aimed at the quantification of the impact of environmental radon on man. Four areas are emphasized: (a) international intercalibration and intercomparison of radon measurement technology; (b) standardization of large scale radon survey techniques; (c) institutionalized exchange of information on radon levels, dosimetric methods and associated risk assessment, and radon mitigation techniques through research co-ordination meetings; and (d) establishment of an international databank on radon.

Consumer products

A Safety Series report on regulatory control of the use of consumer products containing radioactive substances was elaborated.

CRPs established in the current year

Subject	No. of years	Participating institutions
Atmospheric transport model evaluation study (ATMES)	1	4
Radon in the human environment: instrumentation, modelling, dosimetry and surveys	4	47
Radon in the human environment: risk assessment	4	11

Safe transport of radioactive materials

Transport of radioactive materials

In 1990, amended versions of the 1985 Edition of the IAEA Transport Regulations and its supporting documents were published, incorporating all changes since 1985.

In order to provide the same level of protection for all modes of transport, new, more stringent provisions for the air transport of large quantities of radioactive materials were developed for publication as an IAEA-TECDOC.

Transport of UF_6

A final draft of the regulatory provisions for the transport of uranium hexafluoride (UF_6), the only chemical compound of uranium which is used for the commercial enrichment of uranium, was prepared for publication as an IAEA-TECDOC.

Database development

Data on the number of shipments, exposures due to transport activities and accidents and mishaps were considered to be essential for assessing the effectiveness of the Transport Regulations and for future revisions. Progress in 1990 on this issue included:

- Publication of a new directory of national Competent Authority Approval certificates;
- Gathering of data for a database on accidents and incidents during the transport of radioactive materials (EVTRAM);
- Data collection for databases on the number of shipments of radioactive materials associated with the nuclear fuel cycle (SHIPTRAM) and on exposures due to transport activities (EXTRAM).

At the same time, the production of an international computer code for the assessment of the risks of transport operations (INTERTRAN-2), under normal conditions of transport and nuclear accident conditions, was pursued under a CRP aimed at the development of probabilistic safety assessment (PSA) techniques in the subject area. A version of a precursor of this code was completed and distributed to interested parties for benchmarking purposes.

A training manual was published as a direct consequence of recommendations of the Standing Advisory Group on the Safe Transport of Radioactive Material (SAGSTRAM) to co-ordinate activities concerning assistance to Member States in properly implementing the Agency's Transport Regulations. This manual will serve as guidance for lecturers at interregional training courses. Also, the development of visual aids that can be used in connection with such courses was initiated.

The PACKTRAM database on national competent authority package approval certificates underwent modifications. The modified program, together with a user's guide, was distributed to participating Member States.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1986	Radiation protection implications of transport accidents involving radioactive materials	1990	6
1989	Development of probabilistic safety assessment techniques related to the safe transport of radioactive materials	1992	11

Publications

Series and No.	Title
Safety Series No. 6	Regulations for the safe transport of radioactive material, 1985 edition (as amended 1990)
Safety Series No. 7	Explanatory material for the IAEA regulations for the safe transport of radioactive material (1985 edition) — second edition (as amended 1990)
Safety Series No. 37	Advisory material for the IAEA regulations for the safe transport of radioactive material (1985 edition), third edition (as amended 1990)
Safety Series No. 80	Schedules of requirements for the transport of specified types of radioactive material consignments (as amended 1990)
IAEA-TCS-1	Training course series No. 1: safe transport of radioactive material
IAEA-NCAL-21	National competent authorities list, No. 21
IAEA-TECDOC-552	Directory of national competent authorities' approval certificates for package design and shipment of radioactive material, 1990 edition

Emergency planning and preparedness

Emergency Response System

A comprehensive exercise of the Agency's Emergency Response System (ERS), involving approximately 50 staff members, including the Director General and other senior staff, several Member States and other international organizations, was conducted in April 1990 after extensive training. As a result of the exercise, several modifications are being implemented, including changes to the organization and implementation procedures of the ERS and to the Emergency Response Unit.

Rapid post-accident data reporting

The Early Notification and Assistance Conventions require an extensive information exchange during emergencies. Accordingly, the Agency initiated development of specific guidance for Member States and international organizations for managing information and data exchanges during an accident or emergency to avoid confusion and promote the purposes of the Conventions.

Accident notification and emergency assistance

Arrangements have been made with WMO and WHO for support in their respective areas of expertise in the event of a nuclear accident: WMO will provide predictions of the plume path and the expected magnitude of radioactive contamination in the early hours after an accidental release of radioactive materials, while WHO will provide emergency medical advice and assistance following radiological accidents. Co-ordination with other specialized United Nations agencies is progressing through discussions at periodic meetings of the Inter-agency Committee for the Response to Nuclear Accidents.

Publications

Series and No.	Title
Proceedings Series	Recovery operations in the event of a nuclear accident or radiological emergency

Control of radiation sources

Safe handling of sealed and unsealed radiation sources

The Agency has strengthened its activities in the safe use, control and manufacture of radiation sources, with special emphasis on training and on development of practical guidance for competent authorities, users and manufactures. During 1990, the Agency sponsored one interregional training course on the safety and regulation of radiation sources, in Argonne, Illinois, USA. Several reports were completed, including safety manuals, on specific uses of radiation sources (industrial radiography, nuclear gauges and shielded enclosures), a technical report on the radiation safety of gamma and electron irradiation facilities, safety guidance on effectiveness and efficiency in the safety regulation of radiation sources and PSA for large industrial irradiators. These will be published in 1991.

A post-accident review meeting was held on a radiological accident that occurred in June in Israel. The scenario for the accident was very similar to that of the accident in San Salvador (in February 1989). However, the medical treatment of the affected personnel was unique. A report of the accident prepared during the meeting will be published in 1991.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Safety and regulation of radiation sources	USA	28	5 weeks

Publications

Series and No.	Title
Safety Series No. 102	Recommendations for the safe use and regulation of radiation sources in industry, medicine, research and teaching
	The radiological accident in San Salvador

Exposure assessment and handling

Dose per unit intake factors for the public

In following up the implementation of new ICRP recommendations for establishing the annual limits on intake (ALI) for the public, the Agency began preparation of a report on intake coefficients for radionuclides in food. The aim of the report is to give necessary information for calculation of derived levels for the control of environmental contamination due to routine releases of radioactive materials and following a nuclear accident.

Accidental external dose assessment

A new CRP was initiated on the use of natural materials for dose assessment. The CRP is concerned with the application of solid state dosimetry techniques to natural and commonly available materials for accidental dosimetry. The project is to have two main components: (a) experimental, which will explore the extension of the method to new materials, lower doses and improved accuracy, and (b) evaluation, where an assessment will be made of real doses received by members of the population in the town of Pripyat in the USSR due to accidental releases of radionuclides into the atmosphere after the Chernobyl accident. The first research co-ordination meeting took place at Zelenij Mis, near Chernobyl, in July. A substantial quantity of bricks, tiles and porcelain was sampled for laboratory investigation during the field survey in Pripyat.

Overexposure assessment and handling

An interregional training course on radiation cytogenetics in biomedical, environmental, health and radiation protection problems was held in Rio de Janeiro, Brazil. The course was attended by 22 participants from 19 countries, and sought to impart theoretical and practical knowledge in radiation biology and radiation cytogenetics, and especially in current methods of biological dosimetry for radiation protection monitoring.

Preparedness for nuclear and radiological accidents

Two national seminars were held (Indonesia, in March, and Hungary, in September), on preparedness for nuclear and radiological accidents, including medical aspects. The purpose was to identify possible problems that could arise as a result of improvements to infrastructures and systems. A final draft of a report on medical preparedness for radiological accidents was prepared.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1981	Use of chromosomal aberration analysis in radiation protection	1990	14
1988	Dose per unit intake factors for members of the public	1991	11

CRPs established in the current year

Subject	No. of years	Participating institutions
Use of natural materials for dose assessments	3	8

Safety of nuclear installations

Basic principles and criteria

Safety standards and criteria

The Nuclear Safety Standards Advisory Group (NUSSAG) reviewed the revised texts of three Safety Guides, one each from the areas of siting, design and operation. The first deals with earthquakes and associated topics in relation to siting, the second with emergency power supplies and the last with staffing and the training of operational personnel.

A Safety Series publication in the 'Fundamentals' category relating to the safety of nuclear installations was recommended by NUSSAG and its development was started.

INSAG

The Agency's International Nuclear Safety Advisory Group (INSAG) completed its deliberations on the question of safety culture. A report was finalized for publication in early 1991. In addition, INSAG has taken an active role in providing advice on the project on the safety of WWER-440 model 230 reactors.

Regulatory practices

The first round of limited-group peer discussions on regulatory practices was completed. The topic selected for review was regulatory inspection and enforcement.

Publications

Series and No.	Title
Safety Series No. 50-P-1	Application of the single failure criterion
	Nuclear safety review 1990
IAEA-TECDOC-550	Safety of nuclear installations: future direction

Safe siting, design and construction of nuclear installations

Engineering safety review services

In the site safety review missions carried out in 1990, seismic problems were a recurring theme. In some cases the missions involved assessment of fault activity and/or capability; in others, seismic design requirements for structures and equipment were reviewed.

Engineering safety review services related to site and external hazards (1990)

Country	Plant	Service
Poland	Zarnowiecz	Site safety review mission with limited scope
Czechoslovakia	Temelin	Site safety review mission
Iraq	Tikrit	Site survey review mission
Bulgaria	Belene	Site safety review mission
Pakistan	Chashma	Site safety review mission
Romania	Cernavoda	Review of structural non-conformities
Romania	Cernavoda	Review of floor response spectra

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Seismic data for the siting and site re-validation of nuclear facilities	1992	7

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on physical protection of nuclear facilities and materials	USA	27	4 weeks

Safe operation of nuclear installations

Operational safety services

Teams of experts recruited from Member States constructing or operating nuclear power plants carried out seven pre-operational or operational safety review team (pre-OSART/OSART) missions to nuclear power plant sites or plants in six countries. The visits to the existing construction sites revealed a need for basic organizational changes, the application of modern management principles, the introduction of comprehensive quality assurance provisions and reinforced industrial safety practices. The missions to operating nuclear power plants did not reveal any weaknesses of major concern but led to the identification of areas for further improvements in detail.

The OSART guidelines, first issued in 1988, were revised in the light of experience and the development of pre-OSART guidelines neared completion. To deal with the diverse topics covered in the review of technical support in more detail, supplementary guidance and reference material was developed.

OSART missions conducted in 1990

Country	Plant	Type	Power (MW(e))
Spain	Cofrentes	BWR	975
Czechoslovakia	Temelin	WWER	2 × 972
Bulgaria	Belene	WWER	2 × 1000
Romania	Cernavoda	PHWR	5 × 700
Bulgaria	Kozloduy Unit 5	WWER	1000
Finland	Loviisa Units 1 and 2	WWER	2 × 465
China	Guangdong	PWR	2 × 985

ASSET

Growing interest was shown by many countries in the Assessment of Safety Significant Events Team (ASSET) programme and there was a substantial increase in activities in this area.

As part of a series of five ASSET missions requested for the first generation Soviet designed 440 MW(e) model 230 WWERs, three missions took place in 1990: to Greifswald (Germany), Bohunice (Czechoslovakia) and Kozloduy (Bulgaria). Later, an ASSET implementation mission to Greifswald was carried out additionally to assist in implementing the recommended immediate corrective actions.

Two ASSET workshops were organized, one in France on an incident (level 3, INES) that occurred at the Gravelines nuclear power plant, and one in Spain on an incident (level 3, INES) that occurred at Vandellos 1.

ASSET (cont.)

An important activity was the comprehensive preparation of the ASSET implementation mission to the Kanupp pressurized heavy water reactor in Pakistan on the basis of the recommendations of the 1989 ASSET mission to this plant.

ASSET training sessions were a new type of activity started in 1990. These include basic lectures on methods of detection and selection of safety significant events and on the ASSET investigation method, as well as exercises on rating and root cause analysis of selected events. Two training sessions were held, one in Germany and one in Hungary.

ASSET activities in 1990

Country	Plant	Type of activity
Germany	Greifswald	Mission
Germany	Greifswald	Implementation mission
France	Gravelines	Workshop
Germany	Greifswald	Training session
Hungary	Paks	Training session
Czechoslovakia	Bohunice	Mission
Bulgaria	Kozloduy	Mission
Spain	Vandellos	Workshop

Use of unusual events to improve power plant safety

An international seminar on the use of unusual events to improve power plant safety addressed the 'theory and practice' of utilizing information, disseminated through reporting systems, to reinforce nuclear power plant safety. It was the first seminar proposed by the Agency on such a topic and was organized jointly with the OECD/NEA. WANO also participated actively at all stages.

The seminar dealt with the following subject areas: unusual event reporting systems; unusual event reports as a tool for improving safety; event assessment; lessons learned and corrective actions; effect of the feedback process; and objectives and effectiveness of reporting systems. The seminar also discussed new elements in the operating safety experience feedback process which could help the response to new ideas in nuclear safety, international co-operation and communication with the public. The importance of a combination of analytical and practical elements in the safety feedback loop was stressed.

INES

The International Nuclear Event Scale (INES) was finalized and adopted for a one year trial period. The rating of the safety significance of nuclear events, based on seven levels and three attributes (on-site effects, off-site effects and degradation of defence in depth), was described in detail in a user's manual. Although the scale was developed primarily for rapid communication with the public, it was being used increasingly for technical purposes: many Incident Reporting System (IRS) reports adopted INES and ASSETs used it to rate the safety significance of events being studied.

IRS

South Africa and Mexico joined the IRS (operated in co-operation with OECD/NEA), giving a total of 25 Member States as participants. By the end of 1990, the IAEA-IRS file contained 1081 records. The IRS computer database was distributed to participants on diskettes and updated quarterly. The breakdown of the main root cause categories as experienced in all the IAEA-IRS events reported in 1990 is as follows: 48% equipment failure, 26% personnel error and 15% procedural error (with the remaining 11% in other categories). Close relations were maintained with similar services used by the OECD/NEA, WANO and CMEA (Interatomenergo):

- *NEA.* Merging of the two reporting systems was discussed. A joint seminar on the use of unusual event reports for improving nuclear power plant safety took place in Vienna.
- *WANO.* Active participation continued.
- *Interatomenergo.* Co-operation issues were discussed at joint working meetings.

Nuclear power plant ageing

Emphasis was placed in 1990 on improving the awareness of ageing phenomena and on developing methods for evaluation and management. Five reports were completed. A publication (IAEA-TECDOC-540) was issued on the safety aspects of ageing, material ageing mechanisms and the detection and mitigation of ageing effects. Another document (IAEA-TECDOC-547) discusses the use of PSA in relation to plant life extension. Two other documents were prepared for publication: recommended practices for data collection and record keeping and methodologies for the selection of nuclear power plant components whose ageing should be assessed for management studies. Finally, a first draft was prepared of a technical report on current understanding, monitoring and mitigation of ageing effects for four safety significant plant components selected for pilot studies.

Early model WWERs

The safety of older power reactors has become a matter of international concern. The Agency received an increasing number of requests for assistance from Member States operating early WWER reactors. In response, a project for international assistance in assessing the safety of WWER-440 model 230 plants was proposed as a complement to relevant on-going national, bilateral and multilateral activities.

In September, an Advisory Group was convened to establish the technical and organizational basis for the project. The general objective is to assist countries operating the reactors in performing comprehensive safety reviews in the light of all available international experience. These reviews should form the technical basis for the safety decisions which should ultimately be taken by the countries themselves. Specifically, the reviews aim at identifying design and operational weaknesses that may threaten plant safety and at suggesting safety improvements.

A steering committee with specialists from Bulgaria, Czechoslovakia, France, Germany, Spain, Switzerland, the United Kingdom and the USSR was established to monitor the implementation of the project and to give technical guidance.

INSARR

The 324 research reactor facilities operating as of December 1990 provide collective operating experience of more than 10 500 reactor-years. In 1990, Integrated Safety Assessment of Research Reactors (INSARR) missions visited facilities in the Islamic Republic of Iran, the USSR (2) and Bulgaria. The visit to the research reactor in Sofia, Bulgaria, was the 100th INSARR mission conducted since 1972.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on safety in the operation of research reactors	USA	31	5 weeks
International course on operational safety assessment techniques for nuclear power plants using pressurized water reactors	France	13	3 weeks

Publications

Series and No.	Title
IAEA-INES-90/1	INES: the international nuclear event scale, user's manual
IAEA-INES-90/2	Addendum to INES: the international nuclear event scale, user's manual
IAEA-TECDOC-535	Reviewing industrial safety in nuclear power plants
IAEA-TECDOC-540	Safety aspects of nuclear power plant ageing
IAEA-TECDOC-570	OSART mission highlights 1988-1989
IAEA-TECDOC-573	ASSET guidelines

Accident management and mitigation

Severe accident management and containment behaviour

The framework for the development and implementation of an accident management programme was established. The main parts of the programme are the organization of CRPs on severe accident management and containment behaviour and the preparation of documents on: the use of vulnerability evaluation; mitigation of the effects of hydrogen; containment performance under severe accident conditions; and generic symptom oriented emergency operating plans. A major goal is to develop an accident management manual. In 1990, a draft of the manual was prepared and distributed to experts in the field for comments and suggestions.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Severe accident management	1991	10
1989	Containment integrity and effectiveness for accident conditions beyond design basis	1992	6

Training courses and seminars held

Course name	Location	No. of participants	Duration
Training course on accident management	Yugoslavia	25	2 weeks
Training course on accident management	Rep. of Korea	32	2 weeks
Training course on accident management	Mexico	29	2 weeks

Safety assessment techniques

PSA guidelines

With the objective of standardizing probabilistic safety assessment (PSA) methodology, guidance material was prepared. The work included drafting of a main document which is supported by more specific guidance in the areas of computer codes for PSA, treatments of external hazards, common cause failures, human errors, data collection and analysis and performance of independent peer reviews. In addition, a report was prepared addressing the general use of PSA and the use of numerical values, so-called probabilistic safety criteria (PSC), to be used in judging results. These reports will be published in 1991.

PSAPACK

A PC based computer code which allows interactive construction of the event and fault trees which are necessary to perform a level 1 PSA (i.e. calculate core damage probabilities based on analysis of accident sequences) was finalized. The code allows PSA to be used by operating personnel and regulatory inspectors to predict, for example, the effect on safety of taking components out of service under actual operating conditions. The information provided includes impact on core melt probability, likely accident sequences and the ranking of the importance of equipment relevant for safety.

Application of PSA for event analysis

One of the possible applications of plant specific PSA is its use in the analysis of operational events. Work performed during 1990 included methodology development and documentation and the successful completion of three case studies.

IPERS

Three International Peer Review Service (IPERS) missions reviewed progress on PSA for the Borssele plant in the Netherlands, Forsmark 1 and 2 in Sweden and the Cernavoda plant in Romania.

Comparative risk assessment

Work on risk assessment concentrated on the preparation of an 'issue paper' on the comparative environmental and health impact of different energy systems for electricity production. The paper summarizes the state of the art for discussions at the Senior Expert Symposium on Electricity and the Environment, to be held in Helsinki in May 1991. Work was started on establishing a data bank on environmental and health impact information which will allow a better separation into local, regional and global, and short, medium and long term effects, together with an analysis of uncertainties.

Inter-agency risk management project

In co-operation with UNEP, UNIDO and WHO, work progressed on a risk management procedures guide for industrial areas involving potentially hazardous installations. The preparation of the guide is complemented by several case studies providing practical experience. During 1990, case studies significantly progressed in the following countries: Australia, Czechoslovakia, Egypt, Greece, Hungary, India, Netherlands, Philippines and Yugoslavia. An expert mission to assess the causes and consequences of an accident in a beryllium plant in the USSR was organized.

Human reliability analysis

The importance of human reliability in the safe operation of nuclear power plants has been recognized for a number of years. Attention was devoted to the quantitative collection of data on human errors and the improvement of models of human action in order to generate a more realistic representation of human actions in PSAs. A Technical Committee meeting on human reliability data

Human reliability analysis (cont.)

collection and modelling was held with the objective of investigating new trends and developments in Member States and, in particular, discussing the incorporation of these models into PSAs.

Man-machine interface

A symposium on balancing automation and human action was held in Munich, Germany. The 130 participants, representing 28 Member States and three international organizations, reviewed recent developments and discussed directions for future work. The meeting discussed the rapid progress that has been made in recent years in the development of automation technology, with consequent reductions in the cost of equipment. The obvious tendency to increase the use of automation has to be balanced against the need for human control so as to ensure maximum safety and availability. This problem was considered for various aspects of operation, maintenance and testing. Special attention was given to the questions of validation, verification and training.

Use of expert systems

A Technical Committee meeting/workshop to demonstrate expert system software involved 50 participants who presented and demonstrated their products.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Data collection and analysis for probabilistic safety assessments	1991	11
1988	Reference studies on probabilistic modelling of accident sequences	1992	17
1989	Data acquisition for research reactor PSA studies	1991	10

CRPs established in the current year

Subject	No. of years	Participating institutions
Development of safety related expert systems	3	13

Training courses and seminars held

Course name	Location	No. of participants	Duration
National workshop on PSA and PSAPACK utilization	India	20	1 week

Publications

Series and No.	Title
Safety Series No. 50-SG-O7 (Rev. 1)	Maintenance of nuclear power plants
Safety Series No. 50-SG-O8 (Rev. 1)	Surveillance of items important to safety in nuclear power plants
IAEA-TECDOC-538	Human error classification and data collection
IAEA-TECDOC-542	Use of expert systems in nuclear safety
IAEA-TECDOC-543	Procedures for conducting independent peer reviews of probabilistic safety assessment
IAEA-TECDOC-547	The use of probabilistic safety assessment in the relicensing of nuclear power plants for extended lifetimes
IAEA-TECDOC-549	Computer based aids for operator support in nuclear power plants
IAEA-TECDOC-553	Computer codes for level 1 probabilistic safety assessment
IAEA-TECDOC-561	Reviewing computer capabilities in nuclear power plants
IAEA-TC-560.03	Computer aided safety analysis 1989

Safeguards

Safeguards statement

In carrying out the safeguards obligations of the Agency in 1990, the Secretariat, as in previous years, did not detect any event which would indicate the diversion of a significant amount of safeguarded nuclear material — or the misuse of facilities, equipment or non-nuclear material subject to safeguards — for the manufacture of any nuclear weapon, or for any other military purpose, or for the manufacture of any other nuclear explosive device, or for purposes unknown. (In the case of voluntary-offer agreements with nuclear-weapon States, nuclear material subject to safeguards was not withdrawn from safeguards except in conformity with these agreements.) It is considered reasonable to conclude that the nuclear material under Agency safeguards in 1990 remained in peaceful nuclear activities or was otherwise adequately accounted for. This statement is based on all the information available to the Agency, including information derived from safeguards activities conducted in the field and at Headquarters and information provided in reports submitted by States.

Safeguards coverage

As of 31 December 1990, 177 safeguards agreements were in force with 104 States (and with Taiwan, China), compared to 172 agreements with 101 States (and with Taiwan, China) at the end of 1989.

Safeguards agreements pursuant to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) entered into force with:

St. Lucia, in February;
Viet Nam, in February;
Tunisia, in March;
Malta, in November;
Kiribati, in December.

A project agreement for the supply of fuel for a research reactor entered into force with Zaire in September. In addition, the unilateral submission agreement with Algeria covering a research reactor, which had entered into force provisionally in February 1989, entered into force definitively in April 1990.

The NPT safeguards agreement of 7 March 1972 concluded with the German Democratic Republic (INFCIRC/181) is no longer in force as of 3 October 1990. On that date the German Democratic Republic acceded to the Federal Republic of Germany. Consequently, the safeguards agreement of 5 April 1973 between the non-nuclear-weapon States of the European Atomic Energy Community (EURATOM), EURATOM itself and the Agency (INFCIRC/193) now applies to nuclear installations in the former German Democratic Republic.

Safeguards agreements were concluded with Togo (pursuant to NPT) and with Pakistan (covering a miniature neutron source reactor). These agreements have not yet entered into force.

In 1990 safeguards were applied in 42 States under agreements pursuant to NPT or to NPT and the Treaty of Tlatelolco, in one State under an agreement pursuant to the Treaty of Tlatelolco and in ten States under INFCIRC/66/Rev.2-type agreements. (The Agency also applies safeguards to nuclear installations in Taiwan, China.)

In the States that have concluded INFCIRC/153-type agreements with the Agency, safeguards were applied to all peaceful nuclear activities. In some of the States where safeguards were being applied pursuant to INFCIRC/66/Rev.2-type

Number of states having significant nuclear activities at the end of the year indicated

	Number of States		
	1988	1989	1990
States with safeguards applied under NPT or NPT/Tlatelolco agreements	41	42	42
States with safeguards applied under Tlatelolco agreements	1	1	1
States with safeguards applied under INFCIRC/66/Rev.2-type agreements[a]	10	10	9
Nuclear-weapon States with safeguards applied under voluntary-offer agreements	4	4	4
Other nuclear-weapon States	1	1	1
Total number of States with significant nuclear activities	57	58	57

[a] Some States with INFCIRC/66/Rev.2-type agreements which have not yet been suspended, although NPT agreements have entered into force, are listed under NPT agreements only. Nuclear-weapon States with INFCIRC/66/Rev.2-type agreements in force are not included. Safeguards are also applied to nuclear installations in Taiwan, China.

Safeguards coverage (cont.)

agreements, unsafeguarded facilities were known to be in operation or under construction. All nuclear-weapon States have unsafeguarded nuclear fuel cycles.

Voluntary-offer agreements were in force with the five nuclear-weapon States. In accordance with the agreements with four of these States, certain facilities were designated by the Agency for inspection and were inspected. In one of these States, safeguards were also applied at some facilities under INFCIRC/66/Rev.2-type agreements. Preparations continued for the implementation of safeguards pursuant to the voluntary-offer agreement concluded with the fifth nuclear-weapon State.

Status of agreements pursuant to treaty obligations

As of 31 December 1990, safeguards agreements were in force with 86 States pursuant to NPT. For 51 non-nuclear-weapon States party to NPT there is still no safeguards agreement in force in accordance with Article III.4 of the Treaty. As far as the Agency is aware, only two of these States have significant nuclear activities. Safeguards were being applied in these two States pursuant to other agreements pending the entry into force of a safeguards agreement pursuant to NPT.

NPT safeguards agreements have already been concluded with ten of the eleven signatories of the South Pacific Nuclear Free Zone Treaty (Rarotonga Treaty), and safeguards were applied in one of these States pursuant to such an agreement.

Nineteen of the 23 Latin American States party to the Treaty of Tlatelolco have concluded agreements with the Agency pursuant to the Treaty of Tlatelolco, 16 of which are in force. Two States with territories in the zone of application of the Treaty of Tlatelolco have also concluded similar agreements.

The Governments of Argentina and Brazil signed a declaration of common nuclear policy on 28 November, which contained an undertaking to start negotiations with the Agency for the conclusion of a joint safeguards agreement which would have as its basis a common system of accounting and control. Upon conclusion of such an agreement, the two States would adopt pertinent measures leading to the full entry into force for both countries of the Treaty of Tlatelolco.

Situation on 31 December 1990 with respect to the conclusion of safeguards agreements between the Agency and non-nuclear-weapon States in connection with NPT

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Afghanistan	4 February 1970	In force: 20 February 1978	257
Albania	12 September 1990		
Antigua and Barbuda[b]	1 November 1981	Signed: 1 February 1990	
Australia	23 January 1973	In force: 10 July 1974	217
Austria	27 June 1969	In force: 23 July 1972	156
Bahamas	10 July 1973		
Bahrain	5 November 1988		
Bangladesh	27 September 1979	In force: 11 June 1982	301
Barbados	21 February 1980		
Belgium	2 May 1975	In force: 21 February 1977	193
Belize	9 August 1985	Approved by the Board, Feb.1986	
Benin	31 October 1972		
Bhutan	23 May 1985	In force: 24 October 1989	371
Bolivia[b]	26 May 1970	Signed: 23 August 1974	
Botswana	28 April 1969		
Brunei Darussalam	25 March 1985	In force: 4 November 1987	365
Bulgaria	5 September 1969	In force: 29 February 1972	178
Burkina Faso	3 March 1970		
Burundi	19 March 1971		
Cameroon	8 January 1969		
Canada	8 January 1969	In force: 21 February 1972	164
Cape Verde	24 October 1979		
Central African Republic	25 October 1970		
Chad	10 March 1971		
Colombia	8 April 1986		
Congo	23 October 1978		
Costa Rica[b]	3 March 1970	In force: 22 November 1979	278
Côte d'Ivoire	6 March 1973	In force: 8 September 1983	309
Cyprus	10 February 1970	In force: 26 January 1973	189
Czechoslovakia	22 July 1969	In force: 3 March 1972	173
Democratic Kampuchea	2 June 1972		
Democratic People's Republic of Korea	12 December 1985		
Denmark[c]	3 January 1969	In force: 21 February 1977	193
Dominica	10 August 1984		
Dominican Republic[b]	24 July 1971	In force: 11 October 1973	201
Ecuador[b]	7 March 1969	In force: 10 March 1975	231
Egypt	26 February 1981	In force: 30 June 1982	302
El Salvador[b]	11 July 1972	In force: 22 April 1975	232
Equatorial Guinea	1 November 1984	Approved by the Board, June 1986	
Ethiopia	5 February 1970	In force: 2 December 1977	261

Table (cont.)

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Fiji	14 July 1972	In force: 22 March 1973	192
Finland	5 February 1969	In force: 9 February 1972	155
Gabon	19 February 1974	Signed: 3 December 1979	
Gambia	12 May 1975	In force: 8 August 1978	277
Germany, Federal Republic of[d]	2 May 1975	In force: 21 February 1977	193
Ghana	5 May 1970	In force: 17 February 1975	226
Greece[e]	11 March 1970	Accession: 17 December 1981	193
Grenada	19 August 1974		
Guatemala[b]	22 September 1970	In force: 1 February 1982	299
Guinea	29 April 1985		
Guinea-Bissau	20 August 1976		
Haiti[b]	2 June 1970	Signed: 6 January 1975	
Holy See	25 February 1971	In force: 1 August 1972	187
Honduras[b]	16 May 1973	In force: 18 April 1975	235
Hungary	27 May 1969	In force: 30 March 1972	174
Iceland	18 July 1969	In force: 16 October 1974	215
Indonesia	12 July 1979	In force: 14 July 1980	283
Iran, Islamic Republic of	2 February 1970	In force: 15 May 1974	214
Iraq	29 October 1969	In force: 29 February 1972	172
Ireland	1 July 1968	In force: 21 February 1977	193
Italy	2 May 1975	In force: 21 February 1977	193
Jamaica[b]	5 March 1970	In force: 6 November 1978	265
Japan	8 June 1976	In force: 2 December 1977	255
Jordan	11 February 1970	In force: 21 February 1978	258
Kenya	11 June 1970		
Kiribati	18 April 1985	In force: 19 December 1990	390
Korea, Republic of	23 April 1975	In force: 14 November 1975	236
Kuwait	17 November 1989		
Lao People's Democratic Republic	20 February 1970	Approved by the Board, Feb. 1989	
Lebanon	15 July 1970	In force: 5 March 1973	191
Lesotho	20 May 1970	In force: 12 June 1973	199
Liberia	5 March 1970		
Libyan Arab Jamahiriya	26 May 1975	In force: 8 July 1980	282
Liechtenstein	20 April 1978	In force: 4 October 1979	275
Luxembourg	2 May 1975	In force: 21 February 1977	193
Madagascar	8 October 1970	In force: 14 June 1973	200
Malawi	18 February 1986		
Malaysia	5 March 1970	In force: 29 February 1972	182
Maldives	7 April 1970	In force: 2 October 1977	253
Mali	10 February 1970		
Malta	6 February 1970	In force: 13 November 1990	387
Mauritius	25 April 1969	In force: 31 January 1973	190
Mexico[b]	21 January 1969	In force: 14 September 1973	197
Mongolia	14 May 1969	In force: 5 September 1972	188
Morocco	27 November 1970	In force: 18 February 1975	228

Table (cont.)

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Mozambique	4 September 1990		
Nauru	7 June 1982	In force: 13 April 1984	317
Nepal	5 January 1970	In force: 22 June 1972	186
Netherlands[f]	2 May 1975	In force: 21 February 1977	193
New Zealand	10 September 1969	In force: 29 February 1972	185
Nicaragua[b]	6 March 1973	In force: 29 December 1976	246
Nigeria	27 September 1968	In force: 29 February 1988	358
Norway	5 February 1969	In force: 1 March 1972	177
Panama[b]	13 January 1977	Signed : 22 December 1988	
Papua New Guinea	25 January 1982	In force: 13 October 1983	312
Paraguay[b]	4 February 1970	In force: 20 March 1979	279
Peru[b]	3 March 1970	In force: 1 August 1979	273
Philippines	5 October 1972	In force: 16 October 1974	216
Poland	12 June 1969	In force: 11 October 1972	179
Portugal[g]	15 December 1977	Accession: 1 July 1986	193
Qatar	3 April 1989		
Romania	4 February 1970	In force: 27 October 1972	180
Rwanda	20 May 1975		
St. Lucia	28 December 1979	In force: 2 February 1990	379
St. Vincent and the Grenadines	6 November 1984		
Samoa	17 March 1975	In force: 22 January 1979	268
San Marino	10 August 1970	Approved by the Board, Feb.1977	
São Tome and Principe	20 July 1983		
Saudi Arabia	3 October 1988		
Senegal	17 December 1970	In force: 14 January 1980	276
Seychelles	12 March 1985		
Sierra Leone	26 February 1975	Signed: 10 November 1977	
Singapore	10 March 1976	In force: 18 October 1977	259
Solomon Islands	17 June 1981		
Somalia	5 March 1970		
Spain	5 November 1987	Accession: 5 April 1989	193
Sri Lanka	5 March 1979	In force: 6 August 1984	320
Sudan	31 October 1973	In force: 7 January 1977	245
Suriname[b]	30 June 1976	In force: 2 February 1979	269
Swaziland	11 December 1969	In force: 28 July 1975	227
Sweden	9 January 1970	In force: 14 April 1975	234
Switzerland	9 March 1977	In force: 6 September 1978	264
Syrian Arab Republic	24 September 1969		
Thailand	7 December 1972	In force: 16 May 1974	241
Togo	26 February 1970	Signed: 29 November 1990	
Tonga	7 July 1971	Approved by the Board, Feb.1975	
Trinidad and Tobago	30 October 1986		
Tunisia	26 February 1970	In force: 13 March 1990	381
Turkey	17 April 1980	In force: 1 September 1981	295
Tuvalu	19 January 1979	Approved by the Board, Feb.1986	

Table (cont.)

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Uganda	20 October 1982		
Uruguay[b]	31 August 1970	In force: 17 September 1976	157
Venezuela[b]	26 September 1975	In force: 11 March 1982	300
Viet Nam	14 June 1982	In force: 23 February 1990	376
Yemen, Republic of	1 June 1979		
Yugoslavia	3 March 1970	In force: 28 December 1973	204
Zaire	4 August 1970	In force: 9 November 1972	183

[a] The information reproduced in columns (1) and (2) was provided to the Agency by depositary Governments of NPT, and an entry in column (1) does not imply the expression of any opinion on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers. The Table does not contain information relating to the participation of Taiwan, China, in NPT.

[b] The relevant safeguards agreement refers to both NPT and the Treaty of Tlatelolco.

[c] The NPT safeguards agreement with Denmark (INFCIRC/176), in force since 1 March 1972, has been replaced by the agreement of 5 April 1973 between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency (INFCIRC/193) but still applies to the Faroe Islands. Upon Greenland's secession from EURATOM as of 31 January 1985, the Agreement between the Agency and Denmark (INFCIRC/176) re-entered into force as to Greenland.

[d] The NPT safeguards agreement of 7 March 1972 concluded with the German Democratic Republic (INFCIRC/181) is no longer in force with effect from 3 October 1990, on which date the German Democratic Republic acceded to the Federal Republic of Germany.

[e] The application of Agency safeguards in Greece under the agreement INFCIRC/166, provisionally in force since 1 March 1972, was suspended on 17 December 1981, on which date Greece acceded to the agreement of 5 April 1973 (INFCIRC/193) between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency.

[f] An agreement had also been concluded in respect of the Netherlands Antilles (INFCIRC/229). This agreement entered into force on 5 June 1975.

[g] The NPT safeguards agreement with Portugal (INFCIRC/272), in force since 14 June 1979, was suspended on 1 July 1986, on which date Portugal acceded to the agreement between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency of 5 April 1973 (INFCIRC/193).

Situation on 31 December 1990 with respect to the conclusion of safeguards agreements between the Agency and States party to the Treaty of Tlatelolco[a]

States party to the Treaty of Tlatelolco (1)	Date of becoming a party to the Treaty of Tlatelolco (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Antigua and Barbuda[b]	11 October 1983	Signed: 1 February 1990	
Bahamas	26 April 1977		
Barbados	25 April 1969		
Bolivia[b]	18 February 1969	Signed : 23 August 1974	
Colombia	6 September 1972	In force: 22 December 1982	306
Costa Rica[b]	25 August 1969	In force: 22 November 1979	278
Dominican Republic[b]	14 June 1968	In force: 11 October 1973	201
Ecuador[b]	11 February 1969	In force: 10 March 1975	231
El Salvador[b]	22 April 1968	In force: 22 April 1975	232
Grenada	20 June 1975		
Guatemala[b]	6 February 1970	In force: 1 February 1982	299
Haiti[b]	23 May 1969	Signed : 6 January 1975	
Honduras[b]	23 September 1968	In force: 18 April 1975	235
Jamaica[b]	26 June 1969	In force: 6 November 1978	265
Mexico[b, c]	20 September 1967	In force: 14 September 1973	197
Nicaragua[b]	24 October 1968	In force: 29 December 1976	246
Panama[d]	11 June 1971	In force: 23 March 1984	316
Paraguay[b]	19 March 1969	In force: 20 March 1979	279
Peru[b]	4 March 1969	In force: 1 August 1979	273
Suriname[b]	10 June 1977	In force: 2 February 1979	269
Trinidad and Tobago	27 June 1975		
Uruguay[b]	20 August 1968	In force: 17 September 1976	157
Venezuela[b]	23 March 1970	In force: 11 March 1982	300

In addition, there are the following safeguards agreements with States party to Additional Protocol I to the Treaty:[e]

	Netherlands[b]	In force: 5 June 1975	229
	United States of America	In force: 6 April 1989	366

[a] The information reproduced in columns (1) and (2) was taken from the relevant OPANAL status report.

In addition to the States listed in column (1), Argentina has signed the Treaty but not ratified it, while Brazil and Chile have ratified it but have not yet become parties to the Treaty as they have not so far made the declaration provided for in Article 28 of the Treaty. Dominica signed the Treaty on 2 May 1989.

[b] The relevant safeguards agreement refers to both the Treaty of Tlatelolco and NPT.

[c] The application of safeguards under an agreement with Mexico in connection with the Treaty of Tlatelolco which entered into force on 6 September 1968 (INFCIRC/118) was suspended after the conclusion of an agreement with Mexico in connection with both the Treaty of Tlatelolco and NPT (INFCIRC/197).

[d] An agreement has also been concluded in 1988 pursuant to both the Treaty of Tlatelolco and NPT, which has not yet entered into force.

[e] Additional Protocol I refers to States outside Latin America which have de jure or de facto jurisdiction over territories within the limits of the geographical zone established in the Treaty.

Agreements providing for safeguards, other than those in connection with NPT or the Treaty of Tlatelolco, approved by the Board as of 31 December 1990

Party(ies)[a]	Subject	Entry into force	INFCIRC
(While the Agency is a party to each of the following agreements, only the State(s) party to them is (are) listed.)			
(a) *Project agreements*			
Argentina	Siemens SUR-100	13 March 1970	143
	RAEP Reactor	2 December 1964	62
Chile	Herald Reactor	19 December 1969	137
Finland[b]	FiR-1 Reactor	30 December 1960	24
	FINN sub-critical assembly	30 July 1963	53
Greece[b]	GRR-1 Reactor	1 March 1972	163
Indonesia[b]	Additional core-load for TRIGA Reactor	19 December 1969	136
Iran, Islamic Republic of[b]	UTRR Reactor	10 May 1967	97
Jamaica[b]	Fuel for research reactor	25 January 1984	315
Japan[b]	JRR-3	24 March 1959	3
Malaysia[b]	TRIGA-II Reactor	22 September 1980	287
Mexico[b]	TRIGA-III Reactor	18 December 1963	52
	Siemens SUR-100	21 December 1971	162
	Laguna Verde Nuclear Power Plant	12 February 1974	203
Morocco[b]	Fuel for research reactor	2 December 1983	313
Pakistan	PRR Reactor	5 March 1962	34
	Booster rods for KANUPP	17 June 1968	116
Peru[b]	Research reactor and fuel therefor	9 May 1978	266
Philippines[b]	PRR-1 Reactor	28 September 1966	88
Romania[b]	TRIGA Reactor	30 March 1973	206
	Experimental fuel elements	1 July 1983	307
Spain[b]	Coral-I Reactor	23 June 1967	99
Thailand[b]/United States of America	Fuel for research reactor	30 September 1986	342
Turkey[b]	Sub-critical assembly	17 May 1974	212
Uruguay[b]	URR Reactor	24 September 1965	67
Venezuela[b]	RV-1 Reactor	7 November 1975	238
Viet Nam[c]	Fuel for research reactor	1 July 1983	308
Yugoslavia[b]	TRIGA-II Reactor	4 October 1961	32
	Krško Nuclear Power Plant	14 June 1974	213
Zaire[b]	TRICO Reactor	27 June 1962	37
	Fuel for research reactor	20 September 1990	389
(b) *Unilateral submissions*			
Algeria	Research reactor	9 April 1990	361
Albania	All nuclear material and facilities	25 March 1988	359
Argentina	Atucha Power Reactor Facility	3 October 1972	168
	Nuclear material	23 October 1973	202
	Embalse Power Reactor Facility	6 December 1974	224
	Equipment and nuclear material	22 July 1977	250
	Nuclear material, material, equipment and facilities	22 July 1977	251
	Atucha II Nuclear Power Plant	15 July 1981	294
	Heavy water plant	14 October 1981	296
	Heavy water	14 October 1981	297
	Nuclear material	8 July 1982	303

Table (cont.)

Party(ies)[a]	Subject	Entry into force	INFCIRC
Chile	Nuclear material	31 December 1974	256
	Nuclear material	22 September 1982	304
	Nuclear material	18 September 1987	350
Cuba	Nuclear research reactor and fuel therefor	25 September 1980	298
	Nuclear power plant and nuclear material	5 May 1980	281
	Zero-power nuclear reactor and fuel therefor	7 October 1983	311
Democratic People's Republic of Korea	Research reactor and nuclear material for this reactor	20 July 1977	252
India	Nuclear material, material and facilities	17 November 1977	260
	Nuclear power station	27 September 1988	360
	Nuclear material	11 October 1989	374
Pakistan	Nuclear material	2 March 1977	248
	Miniature neutron source reactor	Approved by the Board, February 1990	
Spain	Nuclear material[d]	18 June 1975	221
	Vandellos Nuclear Power Plant[d]	11 May 1981	292
	Specified nuclear facilities[d]	11 May 1981	291*
United Kingdom	Nuclear material	14 December 1972	175
Viet Nam	Research reactor and fuel therefor	12 June 1981	293
(c) *Agreements concluded with nuclear-weapon States on the basis of voluntary offers*			
China	Nuclear material in facilities selected from list of facilities provided by China	18 September 1989	369
France	Nuclear material in facilities submitted to safeguards	12 September 1981	290
Union of Soviet Socialist Republics	Nuclear material in facilities selected from list of facilities provided by the USSR	10 June 1985	327
United Kingdom	Nuclear material in facilities designated by the Agency	14 August 1978	263
United States of America	Nuclear material in facilities designated by the Agency	9 December 1980	288
(d) *Other agreements*			
Argentina/United States of America		25 July 1969	130
Austria[d]/United States of America		24 January 1970	152
Brazil/Germany, Federal Republic of[d]		26 February 1976	237
Brazil/United States of America		31 October 1968	110
Colombia/United States of America		9 December 1970	144
India/Canada[d]		30 September 1971	211
India/United States of America		27 January 1971	154
Iran, Islamic Republic of[d]/United States of America		20 August 1969	127
Israel/United States of America		4 April 1975	249
Japan[d]/Canada[d]		20 June 1966	85
Japan[d]/France		22 September 1972	171

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* Amended in 1985 to cover specified nuclear facilities. The amendment entered into force on 8 November 1985 (INFCIRC/291/Mod.1/Corr.1).

Table (cont.)

Party(ies)[a]	Subject	Entry into force	INFCIRC
Japan/United Kingdom		15 October 1968	125
Korea, Republic of/ United States of America		5 January 1968	111
Korea, Republic of[d]/France		22 September 1975	233
Pakistan/Canada		17 October 1969	135
Pakistan/France		18 March 1976	239
Philippines[d]/United States of America		19 July 1968	120
Portugal[d]/United States of America[e]		19 July 1969	131
South Africa/United States of America		26 July 1967	98
South Africa/France		5 January 1977	244
Spain/Germany, Federal Republic of[d]		29 September 1982	305
Spain/United States of America		9 December 1966	92
Spain/Canada[d]		10 February 1977	247
Sweden[d]/United States of America		1 March 1972	165
Switzerland[d]/United States of America[e]		28 February 1972	161
Turkey[d]/United States of America[e]		5 June 1969	123
Venezuela[d]/United States of America[e]		27 March 1968	122

(e) The Agency also applies safeguards under two agreements (INFCIRC/133 and INFCIRC/158) to the nuclear facilities in Taiwan, China. Pursuant to the decision adopted by the Board of Governors on 9 December 1971 that the Government of the People's Republic of China is the only government which has the right to represent China in the Agency, the relations between the Agency and the authorities in Taiwan are non-governmental. The agreements are implemented by the Agency on that basis.

[a] An entry in this column does not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities or concerning the delimitation of its frontiers.

[b] Agency safeguards are being applied to the items required to be safeguarded under this (these) project agreement(s) pursuant to an agreement in connection with NPT covering the State indicated.

[c] The requirement for the application of safeguards under this agreement is satisfied by the application of safeguards pursuant to the agreement of 12 June 1981 (INFCIRC/293).

[d] Application of Agency safeguards under this agreement has been suspended in the State indicated as the State has concluded an agreement in connection with NPT.

[e] Application of Agency safeguards under this agreement has been suspended in the United States of America in order to comply with a provision of INFCIRC/288.

Planning, direction, co-ordination, control and evaluation

SAGSI

Two regular meetings (the first including a visit to the Federal Republic of Germany) and one working group meeting (in Czechoslovakia) were held by the Standing Advisory Group on Safeguards Implementation (SAGSI). At the first regular meeting, SAGSI initiated a study of new and improved safeguards procedures, with the aim especially of critically examining the various issues involved. SAGSI also advised on the proposed methodology for the development of the safeguards R&D programme and the application of this methodology to the formulation of the R&D activities for 1991–1992. At its second meeting, SAGSI completed its consideration of the 1991–1992 R&D programme and began a more detailed study of the new and improved safeguards procedures.

Effectiveness evaluation

An evaluation of inspection goal attainment for 1989 was made according to the safeguards criteria and the results were reported to the Board of Governors in the Safeguards Implementation Report (SIR). The criteria were communicated to Member States to facilitate their assessment of the credibility of the Agency's verification procedures and to contribute to further co-operation between the States and the Agency in applying safeguards.

The preparation of safeguards criteria to be used for implementation and evaluation purposes in the period 1991–1995 was concluded, account being taken of current practices, criteria and policies and of recommendations provided by SAGSI on long term guidelines for future safeguards implementation under INFCIRC/66 and INFCIRC/153-type agreements.

Support programmes

The new support programme management and administrative procedures were implemented, resulting in an R&D programme which is better focused on projects of highest priority. As a result of increased collaboration between Member State support programmes, there has also been an improvement in programme effectiveness.

A remote access link to the Headquarter's Support Programme Information and Communication System (SPRICS) was installed, tested and put into operation via a public data transmission utility. The United States support programme office is regularly using this facility. Tests are under way to extend this service to support programme offices in Australia, Canada and France.

Additional support provided by Member States

States and organizations representing groups of States having formal support programmes (initiated in the year indicated)		States having R&D contracts and test programmes
Australia	1989	Argentina
Belgium*	1982	Austria
Canada	1977	Bulgaria
European Atomic Energy Community	1981	Czechoslovakia
Finland	1988	Hungary
France	1983	Italy
German Democratic Republic**	1988	Pakistan
Germany, Federal Republic of	1978	Switzerland
Indonesia	1989	Yugoslavia
Japan	1981	
Sweden	1987	
USSR	1982	
United Kingdom	1980	
United States of America	1976	

* Presently inactive.

** Discontinued in the course of 1990.

Safeguards operations

Verification

In carrying out its verification activities, the Agency found a number of discrepancies and anomalies. These were all subject to thorough investigation and follow-up.

Specific inspection activities included the following:

- A new method for carrying out non-destructive assay (NDA) measurements for on-load reactor (OLR) spent fuel bundles placed in concrete canisters for long term storage was successfully tested for the first time in one State.
- 'Cobra' seals, with an improved verification system, were tested successfully and the seals applied to spent fuel assemblies in dry storage canisters at two facilities.
- A revised safeguards approach for light water reactors (LWRs) using MOX fuel was implemented at the beginning of the year.

After discussion with States, more up to date safeguards equipment and techniques were introduced in a number of facilities:

- As part of the programme to install modulated integrated video system (MIVS) closed circuit television systems and to replace the Minolta cameras, the installation of 43 MIVS was completed in 19 facilities.
- To ensure more efficient use of resources, procedures for the joint use of standard NDA equipment was agreed upon and implemented for low enriched uranium (LEU) facilities in one State.
- Improved working practices, including the large scale application of isotope spiking techniques in measurement systems and underwater television in the transfer bay, were introduced at a reprocessing facility.
- The near-real-time accountancy concept was tested at a major MOX facility and should be ready for routine use in 1991. Discussions were initiated on the introduction of this concept at a reprocessing plant.
- The use of the computerized inspection field support system (IFSS) was expanded to include some LEU facilities.
- The concept of short notice random inspections (SNRIs) at multi-unit OLRs to safeguard the core fuel was tested for the first time.
- An advanced safeguards verification system was installed in the handling and storage units at a reprocessing plant for implementation in early 1991.

Negotiation and liaison with States

Committees and other regular forms of contact between the Agency and Member States, including working arrangements with facility operators, continued to make a significant contribution to the further improvement of safeguards implementation:

- The IAEA Regional Offices in Toronto and in Tokyo continued to make a significant contribution to effective and efficient safeguards implementation. Both offices now cover safeguards operations in several States in their respective regions.
- Some progress was made in the negotiation of Subsidiary Arrangements. Two General Parts to Subsidiary Arrangements (two in 1989) and 46 (9 new and 37 revised) Facility Attachments (88 in 1989) entered into force.
- Negotiations were initiated on facility attachments required for a commercial scale enrichment facility and for a large plutonium storage facility.
- Discussions were initiated on verification problems encountered at the storage facility of a large scale reprocessing plant.

Safeguards inspection verification activities

	1988	1989	1990
Inspections performed	2 128	2 196	2 188
Person-days of inspection	9 379	10 132	10 381
Seals applied to nuclear material or Agency safeguards equipment detached and subsequently verified (including seals applied jointly with a group of States)	28 700	24 800	26 600
Surveillance films developed at Headquarters	1 650	1 860	1 900
Surveillance films developed in the field	1 400	1 460	1 400
Plutonium and uranium samples analysed	1 170	1 200	1 510
Analytical results reported	3 040	2 890	3 890

Approximate quantities of material subject to Agency safeguards at the end of 1990

Type of material	Quantity of material (t)			
	INFCIRC/153[a]	INFCIRC/66[b]	Nuclear-weapon States	Quantity in SQ
Nuclear material				
Plutonium[c] contained in irradiated fuel	212.4[d]	22.2	75.0	38 710
Separated plutonium outside reactor cores	8.5	0	11.6	2 516
Recycled plutonium in fuel elements in reactor cores	1.8	0	0	220
HEU (equal to or greater than 20% uranium-235)	11.3	0.4	0	268
LEU (less than 20% uranium-235)	25 849	2 084	7 678	10 900
Source material[e] (natural or depleted uranium and thorium)	39 520	2 821	19 765	4 618
Total significant quantities				*57 232*
Non-nuclear material[f]				
Heavy water	0	1 785	0	89

[a] Covering safeguards agreements pursuant to NPT and/or Treaty of Tlatelolco.

[b] Excluding installations in nuclear-weapon States; including installations in Taiwan, China.

[c] The quantity includes an estimated 64.3 t (8039 SQ) of plutonium in irradiated fuel, which is not yet reported to the Agency under the agreed reporting procedures (the non-reported plutonium is contained in irradiated fuel assemblies to which item accountancy and containment and surveillance (C/S) measures are applied).

[d] Includes plutonium previously included in the inventory of a State under INFCIRC/66/Rev.2-type agreements and which has not yet been covered by INFCIRC/153-type State reports.

[e] This table does not include material within the terms of subparagraphs 34(a) and (b) of INFCIRC/153 (Corrected).

[f] Non-nuclear material subject to Agency safeguards under INFCIRC/66/Rev.2-type agreements.

Number of installations under safeguards or containing safeguarded material on 31 December 1990

Installation category	Number of installations			
	INFCIRC/153[a]	INFCIRC/66 Rev. 2[b]	Nuclear-weapon States	Total[c]
Power reactors	168	16	1	185 (183)
Research reactors and critical assemblies	146	23	1	170 (173)
Conversion plants	6	3	0	9 (8)
Fuel fabrication plants	34	9	2	45 (43)
Reprocessing plants	4	1	0	5 (5)
Enrichment plants	5[d]	1	1	7 (7)
Separate storage facilities	37	5	4	46 (45)
Other facilities	45	3	0	48 (51)
Subtotals	445	61	9	515 (515)
Other locations	368	27	0	395 (405)
Non-nuclear installations	0	2	0	2 (2)
Totals	813	90	9	912 (922)

[a] Covering safeguards agreements pursuant to NPT and/or Treaty of Tlatelolco.

[b] Excluding installations in nuclear-weapon States; including installations in Taiwan, China.

[c] Numbers for 1989 are indicated in parentheses for comparison.

[d] Including two locations associated with enrichment technology.

Facilities under Agency safeguards or containing safeguarded material on 31 December 1990

Power reactors

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Argentina	Atucha NPS	Lima	x
	Embalse PR	Embalse	—
Belgium	BR3	Mol	x
	DOEL-1	Doel	x
	DOEL-2	Doel	x
	DOEL-3	Doel	x
	DOEL-4	Doel	x
	Tihange-1	Tihange	x
	Tihange-2	Tihange	x
	Tihange-3	Tihange	x
Brazil	Angra-1	Angra dos Reis	x
Bulgaria	Kozloduy-I, Unit 1	Kozloduy	x
	Kozloduy-I, Unit 2	Kozloduy	x
	Kozloduy-II, Unit 1	Kozloduy	x
	Kozloduy-II, Unit 2	Kozloduy	x
	Kozloduy-III, Unit 1	Kozloduy	x
	Kozloduy-III, Unit 2	Kozloduy	x
Canada	Bruce A, Unit 1	Tiverton	x
	Bruce A, Unit 2	Tiverton	x
	Bruce A, Unit 3	Tiverton	x
	Bruce A, Unit 4	Tiverton	x
	Bruce B, Unit 5	Tiverton	x
	Bruce B, Unit 6	Tiverton	x
	Bruce B, Unit 7	Tiverton	x
	Bruce B, Unit 8	Tiverton	x
	Darlington A, Unit 1	Bowmanville	x
	Darlington A, Unit 2	Bowmanville	x
	Gentilly-2	Gentilly	x
	Pickering A, Unit 1	Pickering	x
	Pickering A, Unit 2	Pickering	x
	Pickering A, Unit 3	Pickering	x
	Pickering A, Unit 4	Pickering	x
	Pickering B, Unit 5	Pickering	x
	Pickering B, Unit 6	Pickering	x
	Pickering B, Unit 7	Pickering	x
	Pickering B, Unit 8	Pickering	x
	Point Lepreau G.S.	Point Lepreau	x
Czechoslovakia	Al	Bohunice	x
	EDU-1, Unit 1	Dukovany	x
	EDU-1, Unit 2	Dukovany	x
	EDU-2, Unit 1	Dukovany	x
	EDU-2, Unit 2	Dukovany	x
	V-1, Unit 1	Bohunice	x
	V-1, Unit 2	Bohunice	x
	V-2, Unit 1	Bohunice	x
	V-2, Unit 2	Bohunice	x

Power reactors (cont.)

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Finland	Loviisa-1	Loviisa	x
	Loviisa-2	Loviisa	x
	TVO-1	Olkiluoto	x
	TVO-2	Olkiluoto	x
Germany, Federal Republic of	AVR	Jülich	—
	GKW Grohnde	Grohnde	—
	GKN-2	Neckarwestheim	x
	KKW Biblis-A	Biblis	x
	KKW Biblis-B	Biblis	x
	KKW Brokdorf	Brokdorf	—
	KKW Brunsbüttel	Brunsbüttel	x
	KKW Emsland	Lingen	x
	KKW Grafenrheinfeld	Grafenrheinfeld	—
	KKW Isar	Ohu bei Landshut	x
	KKW Isar-2	Essenbach	—
	KKW Krümmel	Geesthacht	x
	KKW Mülheim-Kärlich	Mülheim-Kärlich	x
	KKW Neckarwestheim	Neckarwestheim	x
	KKW Obrigheim	Obrigheim	x
	KKW Philippsburg-1	Philippsburg	x
	KKW Philippsburg-2	Philippsburg	—
	KKW RWE-Bayernwerk II, Block B	Gundremmingen	x
	KKW RWE-Bayernwerk II, Block C	Gundremmingen	x
	KKW Stade	Stade	x
	KKW Unterweser	Stadland	x
	KKW Würgassen	Würgassen	x
	KFK-MZFR	Eggenstein-Leopoldshafen	x
	KNK	Eggenstein-Leopoldshafen	x
	Thorium Hochtemperatur Reaktor	Hamm	—
	VEB Bruno Leuschner-1, Unit 1	Greifswald	—
	VEB Bruno Leuschner-1, Unit 2	Greifswald	—
	VEB Bruno Leuschner-2, Unit 3	Greifswald	—
	VEB Bruno Leuschner-2, Unit 4	Greifswald	—
	VEB Bruno Leuschner-3, Unit 5	Greifswald	—
	VEB Rheinsberg	Rheinsberg	—
Hungary	PAKS-I, Unit 1	Paks	x
	PAKS-I, Unit 2	Paks	x
	PAKS-II, Unit 1	Paks	x
	PAKS-II, Unit 2	Paks	x
India	RAPS, Unit 1	Rajasthan	x
	RAPS, Unit 2	Rajasthan	x
	TAPS, Unit 1	Tarapur	x
	TAPS, Unit 2	Tarapur	x
Italy	ENEL	Borgo-Sabatino	x
	C.N. del Garigliano	Sessa Aurunca	x
	C.N. Caorso	Caorso	x
	C.N. Enrico Fermi	Trino-Vercellese	x

Power reactors (cont.)

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Japan	Fugen	Tsuruga-Fukui	x
	Fukushima Dai-Ichi-1	Okuma-Fukushima	x
	Fukushima Dai-Ichi-2	Okuma-Fukushima	x
	Fukushima Dai-Ichi-3	Okuma-Fukushima	x
	Fukushima Dai-Ichi-4	Okuma-Fukushima	x
	Fukushima Dai-Ichi-5	Okuma-Fukushima	x
	Fukushima Dai-Ichi-6	Okuma-Fukushima	x
	Fukushima Dai-Ni-1	Naraha-Fukushima	x
	Fukushima Dai-Ni-2	Naraha-Fukushima	x
	Fukushima Dai-Ni-3	Naraha-Fukushima	x
	Fukushima Dai-Ni-4	Naraha-Fukushima	x
	Genkai-1	Kyushu	x
	Genkai-2	Kyushu	x
	Hamaoka-1	Hamaoka-cho	x
	Hamaoka-2	Hamaoka-cho	x
	Hamaoka-3	Hamaoka-cho	x
	Ikata-1	Nishiuwa-gun	x
	Ikata-2	Nishiuwa-gun	x
	Kashiwazaki-1	Niigata	x
	Kashiwazaki-2	Niigata	x
	Kashiwazaki-5	Niigata	x
	Mihama-1	Mihama-Fukui	x
	Mihama-2	Mihama-Fukui	x
	Mihama-3	Mihama-Fukui	x
	Ohi-1	Ohi-cho, Fukui-ken	x
	Ohi-2	Ohi-cho, Fukui-ken	x
	Onagawa-1	Miyaki-ken	x
	Sendai-1	Sendai	x
	Sendai-2	Sendai	x
	Shimane-1	Kashima-cho	x
	Shimane-2	Kashima-cho	x
	Takahama-1	Takahama	x
	Takahama-2	Takahama	x
	Takahama-3	Takahama	x
	Takahama-4	Takahama	x
	Tokai-1	Tokai-Mura	x
	Tokai-2	Tokai-Mura	x
	Tomari-1	Tomari-Mura	x
	Tomari-2	Tomari-Mura	x
	Tsuruga-1	Tsuruga	x
	Tsuruga-2	Tsuruga	x
Korea, Republic of	Kori-1	Pusan	x
	Kori-2	Pusan	x
	Kori-3	Pusan	x
	Kori-4	Pusan	x
	Uljin-1	Uljin	x
	Uljin-2	Uljin	x
	Wolsung-1	Ulsan	x
	Youngwang 1	Pusan	x
	Youngwang 2	Pusan	x

Power reactors (cont.)

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Mexico	Laguna Verde 1	Alto Lucero	x
Netherlands	Borssele	Borssele	x
	Dodewaard NPP	Dodewaard	x
Pakistan	KANUPP	Karachi	x
Philippines	PNPP-1	Morong, Bataan	x
South Africa	Koeberg-1	Cape Town	x
	Koeberg-2	Cape Town	x
Spain	Almaraz-1	Almaraz	—
	Almaraz-2	Almaraz	—
	Asco-1	Asco	—
	Asco-2	Asco	—
	Cofrentes	Cofrentes	—
	José Cabrera	Almonazid de Zorita	—
	Santa María de Garona	Santa María de Garona	—
	Trillo-1	Trillo	—
	Vandellos 1	Vandellos	—
	Vandellos 2	Vandellos	—
Sweden	Barsebäck I	Malmö	x
	Barsebäck II	Malmö	x
	Forsmark I	Uppsala	x
	Forsmark II	Uppsala	x
	Forsmark III	Uppsala	x
	Oskarshamn I	Oskarshamn	x
	Oskarshamn II	Oskarshamn	x
	Oskarshamn III	Oskarshamn	x
	Ringhals I	Göteborg	x
	Ringhals II	Göteborg	x
	Ringhals III	Göteborg	x
	Ringhals IV	Göteborg	x
Switzerland	KKB-I	Beznau	x
	KKB-II	Beznau	x
	KKG	Gösgen-Däniken	x
	KKL	Leibstadt	x
	KKM	Mühleberg	x
Union of Soviet Socialist Republics	Novo Voronezh Unit 5	Novo Voronezh	x
Yugoslavia	Křsko	Krško	x

Research reactors and critical assemblies

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Algeria	NUR Reactor	Wilaya de Tipaza	—
Argentina	RA-1	Constituyentes	x
	RA-2	Constituyentes	x
	RA-3	Ezeiza	x
	RA-4	Rosario	x
	RA-6	Bariloche	x
	RA-O	Cordoba	—
Australia	HIFAR	Lucas Heights	x
	MOATA	Lucas Heights	x
	CF	Lucas Heights	x
Austria	ASTRA	Seibersdorf	x
	SAR	Graz	x
	Triga II	Vienna	x
Bangladesh	Atomic Energy Research Est.	Ganakbari Savar Dhaka	x
Belgium	BRO2	Mol	x
	BR1-CEN	Mol	x
	BR2-CEN	Mol	x
	CEN-Venus	Mol	x
	Thetis	Gent	x
Brazil	IEAR-1	São Paulo	x
	RIEN-1	Rio de Janeiro	x
	Triga-CDTN	Belo Horizonte	x
Bulgaria	IRT-2000	Sofia	x
Canada	McMaster	Hamilton	x
	NRU	Chalk River	x
	NRX	Chalk River	x
	PTR	Chalk River	x
	Slowpoke-AECL	Ottawa	x
	Slowpoke-Dalhousie Univ.	Halifax	x
	Slowpoke-Ecole Polytechnique	Montreal	x
	Slowpoke-Kingston	Kingston	x
	Slowpoke-Saskatchewan	Saskatoon	x
	Slowpoke-Toronto University	Toronto	x
	Slowpoke-Univ. of Alberta	Edmonton	x
	WR-1	Pinawa	x
	ZED-2	Chalk River	x
Chile	La Reina	Santiago	x
	Lo Aguirre	Santiago	x
Colombia	IAN-R1	Bogotá	x
Czechoslovakia	LR-O	Řež	x
	SR-OD	Vochov	x
	Univ. Training Reactor VR-1P	Prague	x
	VVR-S	Řež	x
Democratic People's Republic of Korea	Critical assembly	Nyonphyon	x
	IRT-DPRK	Nyonphyon	x
Denmark	DR-1	Roskilde	x
	DR-3	Roskilde	x

Research reactors and critical assemblies (cont.)

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Egypt	Nuclear Research Centre	Inshas	x
Finland	Triga II	Otaniemi	x
Germany, Federal Republic of	BER-2	Berlin	x
	FMRB	Braunschweig	x
	FRF-2	Frankfurt	x
	FRM	Garching	x
	GKSS-FRG1	Geesthacht	x
	GKSS-FRG2	Geesthacht	x
	KFA-FRJ1	Jülich	x
	KFA-FRJ2	Jülich	x
	SUR 100	Bremen	x
	SUR 100	Eggenstein-Leopoldshafen	x
	SUR 100	Hannover	x
	SUR 100	Kiel	x
	SUR 100	Hamburg	x
	SUR 100	Ulm	x
	SUR 100	Stuttgart	x
	SUR 100	Furtwangen	x
	SUR 100	Darmstadt	x
	SUR 100	Berlin	x
	SUR 100	Aachen	x
	Tech. Univ. AKR	Dresden	—
	Tech. Hochschule ZLR	Zittau	—
	Triga	Mainz	x
	Triga	Hannover	x
	Triga II	Heidelberg	x
	ZFK RAKE	Rossendorf	—
	ZFK research reactor	Rossendorf	—
	ZFK RRR	Rossendorf	—
Greece	GRR-1	Attiki	x
Hungary	Training reactor	Budapest	x
	WWR-S M	Budapest	x
	ZR-6	Budapest	x
Indonesia	Gama	Yogyakarta	x
	MPR-30	Serpong	x
	PPTN	Bandung	x
Iran, Islamic Republic of	TSPRR	Teheran	x
Iraq	IRT-5000	Baghdad Tuwaitha	x
	Tamuz-2	Baghdad Tuwaitha	x
Israel	IRR-1	Soreq	x
Italy	AGN-201	Palermo	x
	CESNEF-L54	Milan	x
	ESSOR	Ispra	x
	RB-3	Montecuccolino	x
	RTS-1	San Piero a Grado	x
	TAPIRO	Santa Maria di Galeria	x
	Triga-RC1	Santa Maria di Galeria	x
	Triga-2	Pavia	x

Research reactors and critical assemblies (cont.)

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Jamaica	Centre for Nuclear Sciences	Kingston	x
Japan	DCA	Oarai-Machi	x
	FCA	Tokai-Mura	x
	HTR	Kawasaki-shi	x
	JMTR	Oarai-Machi	x
	JMTR-CA	Oarai-Machi	x
	JOYO	Oarai-Machi	x
	JRR-2	Tokai-Mura	x
	JRR-3	Tokai-Mura	x
	JRR-4	Tokai-Mura	x
	Kinki University R.R.	Kowake	x
	KUCA	Kumatori-cho	x
	KUCA	Kumatori-cho	x
	KUCA	Kumatori-cho	x
	KUR	Kumatori-cho	x
	Musashi College R.R.	Kawasaki	x
	N.S. Mutsu	Minato-Machi	x
	NCA	Kawasaki-ku	x
	NSRR	Tokai-Mura	x
	Rikkyo University R.R.	Nagasaka	x
	TCA	Tokai-Mura	x
	TODAI	Tokai-Mura	x
	TTR	Kawasaki-shi	x
	VHTRC	Tokai-Mura	x
Korea, Republic of	Triga II	Seoul	x
	Triga III	Seoul	x
	Kyung-Hee Univ.	Seoul	x
Libyan Arab Jamahiriya	IRT-Tajura	Tajura	x
Malaysia	Puspati	Bangi, Selangor	x
Mexico	Triga III	Ocoyoacac	x
	SUR 100	Mexico City	x
Netherlands	HOR	Delft	x
	HFR	Petten	x
	LFR	Petten	x
Norway	HBWR-Halden	Halden	x
	JEEP-II	Kjeller	x
Pakistan	PARR	Rawalpindi	x
Peru	Centro nucl. de investigaciones	San Borja	x
	RP-O	Lima	x
Philippines	PRR-1	Diliman, Quezon City	x
Poland	Agata	Świerk	x
	Anna	Świerk	x
	Ewa	Świerk	x
	Maria	Świerk	x
Portugal	RPI	Sacavem	x

Research reactors and critical assemblies (cont.)

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Romania	RP-01	Magurele	x
	Triga II	Piteşti Colibaşi	x
	VVR-S	Magurele	x
South Africa	SAFARI-1	Pelindaba	x
Spain	ARBI	Bilbao	—
	ARGOS	Barcelona	—
	JEN-1 and JEN-2	Madrid	—
Sweden	R2	Studsvik	x
	R2-O	Studsvik	x
Switzerland	AGN 211P	Basel	x
	Crocus	Lausanne	x
	Proteus	Würenlingen	x
	Saphir	Würenlingen	x
Thailand	TRR-1	Bangkok	x
Turkey	TR-1	Istanbul	x
	ITU-TRR	Istanbul	x
Union of Soviet Socialist Republics	IR-8 Research Reactor	Moscow	x
Uruguay	Lockheed	Montevideo	x
Venezuela	RV-I	Altos de Pipe	x
Viet Nam	Da Lat Research Reactor	Da Lat	—
Yugoslavia	RA	Vinča	x
	RB	Vinča	x
	Triga II	Ljubljana	x
Zaire	Triga-Zaire	Kinshasa	x

Conversion plants, including pilot plants

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Argentina	UO_2 Conversion Plant	Cordoba	—
	Uranium Powders Fabrication Plant	Constituyentes	—
Canada	CAMECO	Port Hope	x
Japan	Japan Nuclear Fuel Conversion Co. Ltd.	Tokai-Mura	x
	Ningyo R & D	Ningyo	x
	PCDF	Tokai-Mura	x
Mexico	UO_2 Conversion Plant	Salazar	—
Romania	UO_2 powder fab. plant	Feldioara	—

Fuel fabrication plants, including pilot plants

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Argentina	Atucha Fuel Fabrication Plant	Ezeiza	—
	Fuel Fabrication Plant (CANDU)	Ezeiza	—
	Pilot Fuel Fabrication Plant (HEU)	Constituyentes	x
	Research Reactor Fuel Fab. Plant	Constituyentes	—
Belgium	Belgonucléaire-BN-MOX	Dessel	x
	FBFC	Dessel	x
	FBFC MOX Assembling Facility	Dessel	—
Brazil	Fuel Fabrication Plant Resende	Resende	x
Canada	GEC	Peterborough	x
	GEC	Toronto	x
	Fuel fabrication facility	Chalk River	—
	CRNL Fuel Fabrication	Chalk River	x
	Zircatec P.I. Ltd.	Port Hope	x
Denmark	Metallurgy	Roskilde	x
Germany, Federal Republic of	Exxon	Lingen	x
	NUKEM	Wolfgang	x
	Siemens Uran	Hanau	x
	Siemens Uran	Karlstein	x
	Siemens MOX	Hanau	x
India	EFFP-NFC	Hyderabad	x
	Ceramic fuel fab. assembly area	Hyderabad	x
Indonesia	Experimental Fuel Element Installation (IEBE)	Serpong	x
	Research Reactor Fuel Element Production Installation (IPEBRR)	Serpong	x
Iraq	ERLFF	Baghdad Tuwaitha	x
Italy	COREN	Saluggia	x
	Fabnuc	Bosco Marengo	x
	IFEC	Saluggia	x
Japan	JNF	Yokosuka	x
	MNF	Tokai-Mura	x
	NFI (Kumatori-1)	Kumatori, Osaka	x
	NFI (Kumatori-2)	Kumatori, Osaka	x
	NFI (Tokai) Fuel Fabrication	Tokai-Mura	x
	PFPF	Tokai-Mura	x
	PPFF	Tokai-Mura	x
Korea, Republic of	CFFP	Daejeon	x
	LEU Fuel Fabrication	Daejeon	x
Mexico	Fuel Fabrication Plant	Ocoayacac	—
Romania	Romfuel	Piteşti Colibaşi	x
Spain	CIEMAT Planta Metall.	Madrid	—
	ENUSA Fuel Fabrication Plant	Juzbado	—
Sweden	ASEA-ATOM	Västeras	x
United States of America	General Electric Co.	Wilmington, NC	x
	Babcock & Wilcox Co.	Lynchburg, VA	x

Chemical reprocessing plants, including pilot plants

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Germany, Federal Republic of	WAK	Eggenstein-Leopoldshafen	x
India	PREFRE	Tarapur	x
Italy	EUREX	Saluggia	x
	ITREC-Trisaia	Rotondella	x
Japan	Tokai Reprocessing Plant	Tokai-Mura	x

Enrichment plants, including pilot plants

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Brazil	Sep. Noz. Enrichment Plant	Resende	x
Germany, Federal Republic of	Uranit*	Jülich	—
	URENCO Deutschland, UTA-1	Gronau	x
Japan	Uranium Enrichment Plant	Ningyo	x
Netherlands	Ultra-Centrifuge*	Almelo	—
	URENCO Nederland	Almelo	x
United Kingdom	BNFL Centrifuge plant and associated storage	Capenhurst	x

* Location associated with enrichment technology.

Separate storage facilities

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Argentina	Storage of zircaloy tubes	Ezeiza	—
	Storage of depleted hexafluoride	Bariloche	—
	Storage of 20% enriched uranium	Cac	—
Belgium	BN UF_6 store	Dessel	x
	Belgoprocess	Mol	x
Bulgaria	AFRS	Kozloduy	—
Canada	Bruce A	Tiverton	x
	Bruce B	Tiverton	x
	CRNL	Chalk River	x
	CRNL spent fuel dry store	Chalk River	—
	Douglas Point	Tiverton	x
	Gentilly-1	Gentilly	x
	Long term storage at CRNL	Chalk River	—
	Pickering	Pickering	x
	WNRE	Pinawa	x
Chile	Lab. experimental de conversión	Santiago	x
Czechoslovakia	AFRS	Bohunice	x
Denmark	Risø Store	Roskilde	x
	Risø Waste	Roskilde	—
Finland	Long term storage for TVO	Olkilouto	—
France	COGEMA UP2 spent fuel storage ponds	La Hague	x
Germany, Federal Republic of	Bundeslager	Wolfgang	—
	Exxon Nuclear UF6 Lageranlage	Lingen	x
	KFK-FR-2	Eggenstein-Leopoldshafen	x
	KFA Jülich Lager (AVR Kugeln)	Jülich	x
	LSG UF_6 Freilager	Hanau	—
	TNH GesmbH	Landsbergen-Leese	—
	Nuclear Cargo & Services	Hanau	—
	Urananlage	Birkenfeld	x
	VEB Greifswald	Greifswald	—
Iraq	Separate storage facility	Baghdad Tuwaitha	x
Italy	Avogadro	Saluggia	x
	Deposito Prodotti Uraniferi	Bosco Marengo	x
	Essor Nuclear Plant	Ispra	—
	Essor Storage Pond	Ispra	—
	Ispra Central Storage	Ispra	x
	Joint Research Centre	Ispra	—
Japan	KUFFS	Kyoto	x
Luxembourg	International Metals S.A.	Luxembourg-Dommeldange	x
Pakistan	Storage at Government depot	Karachi Malir	x
Portugal	Instalação de Armazenagem	Sacavem	x
Sweden	Central long term storage	Oskarshamn	—
Switzerland	Diorit Storage	Würenlingen	x
United Kingdom	BNF PLC Store 9	Sellafield	x
	Sellafield Pu-storage	Sellafield	x
	Oxide Fuel Storage Pond	Sellafield	x

Other facilities

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Argentina	Lab. de Calificación	Constituyentes	—
Australia	Research Laboratory	Lucas Heights	x
Belgium	BCMN	Geel	x
	CEN-Labo	Mol	x
	CEN-Waste	Mol	—
	I.R.E.	Fleurus	x
	PULAB	Mol	x
Canada	Physics, Chemistry, Fuel Eng., Health Phys., R & D	Chalk River	x
Czechoslovakia	Nuclear Fuel Inst. (UJP)	Zbraslav	x
	Research Laboratories	Řež	x
Denmark	Hotcell Plant	Roskilde	x
Germany, Federal Republic of	KFA-heisse Zellen	Jülich	x
	Institut für Kernphysik-1	Eggenstein-Leopoldshafen	x
	KFK-heisse Zellen	Eggenstein-Leopoldshafen	x
	KFK/IHCH	Eggenstein-Leopoldshafen	x
	KFK/IMF3	Eggenstein-Leopoldshafen	x
	KWU-heisse Zellen	Karlstein	x
	Lab. d. KFA Jülich	Jülich	x
	Transuran	Eggenstein-Leopoldshafen	x
	Urantechnikum	Rossendorf	—
Hungary	Institute of Isotopes	Budapest	x
Italy	CNEN-LAB. PU.	Santa Maria di Galeria	x
	CNEN-LAB. TEC.	Santa Maria di Galeria	x
Japan	JAERI-Oarai R&D	Oarai-Machi	x
	JAERI-Tokai R&D	Tokai-Mura	x
	NDC Fuel Hot Lab	Tokai-Mura	x
	NERL, University of Tokyo	Tokai-Mura	x
	NFD	Oarai-Machi	x
	NFI Tokai II	Tokai-Mura	x
	NRF Neutron Radiation Facility	Tsukuba	x
	NDC fuel laboratories	Tokai-Mura	x
	PNC FMF	Oarai-Machi	x
	PNC IRAF	Oarai-Machi	x
	PNC-Oarai R&D	Oarai-Machi	x
	PNC Tokai R&D	Tokai-Mura	x
	Uranium material laboratory	Oarai-Machi	x
Korea, Republic of	PIEF	Daejeon	x
Netherlands	ECN & JRC	Petten	x
	Kema Lab.	Arnhem	x
Norway	Research laboratories	Kjeller	x

Other facilities (cont.)

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Poland	Institute for nuclear chemistry and engineering	Warsaw	—
	Institute of Nuclear Research	Świerk	x
	Miscellaneous locations combined in one material balance area	Various	x
South Africa	Hot Cell Complex	Pelindaba	x
Spain	CIEMAT Lab-Pu	Madrid	—
Sweden	Central storage fresh fuel	Studsvik	x
Switzerland	Fed. Inst. of Reactor Research	Würenlingen	x

Non-nuclear installations

State[a]	Abbreviated name of installation	Location	Subsidiary arrangements in force
Argentina	Heavy water plant	Arroyito	—
	Heavy water storage	Buenos Aires	x

[a] An entry in this column does not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

Note: The Agency also was applying safeguards in Taiwan, China, at six power reactors, six research reactors/critical assemblies, one uranium pilot conversion plant, two fuel fabrication plants and one research and development facility.

Safeguards support

Safeguards systems for:
— fuel fabrication plants

At a major MOX fuel fabrication plant further work was done on authentication and acceptance testing of major installed equipment. Procedures for verification of in-process, hold-up and scrap materials were introduced.

Design work continued on the safeguards system for a new automated MOX fuel fabrication plant. Agreement in principle has been reached on the safeguards approach to be used for the facility and discussions have begun regarding contractual aspects of the project. Significant contributions to the development work have been provided through Member State support programmes and by facility operators.

— multi-unit nuclear power stations

The core discharge monitor (CDM) installed at a unit of a multi-unit OLR nuclear power station was tested and preliminary results proved to be excellent. The number of irradiated fuel bundles discharged from the reactor core at full power can readily be determined from the system output and unusual fuel handling events can be verified. In the light of practical experience gained so far and in the interim period before the successful commissioning of the CDMs, the inspection effort for the complementary regime of SNRIs was reduced with account taken of the use of the CDMs at this stage as reactor vault radiation monitors.

— heavy water production plants

The programme for the preparation, testing and evaluation of equipment and concepts for the implementation of safeguards at a heavy water production plant has continued.

System studies

Work on the implementation and further development of a new safeguards approach for a multi-unit OLR station under construction continued. Interim safeguards measures are under development for the reactor cores of the CANDU-type OLRs already operating.

In consultation with Member States and SAGSI, the Agency has initiated a programme to develop safeguards requirements and methodologies for geological repositories and to formulate a safeguards policy well before such facilities start operation.

The development of technical criteria for the termination of safeguards on nuclear material categorized as measured discards continued.

Work continued on safeguards approaches for new, large scale reprocessing plants. Both generic and facility specific issues relating to spent fuel storage, continuous dissolution head-end systems, advanced accountancy methods and plutonium product storage were addressed.

The Agency continued participation in multinational meetings under the auspices of LASCAR (Large Scale Reprocessing Plant Safeguards). Following the completion of studies on spent fuel storage and head-end dissolution, discussions were focused on the main process area and product storage systems. The LASCAR studies will provide a useful compendium of technical alternatives for safeguarding large reprocessing plants.

A safeguards approach for LEU fuel fabrication plants involving SNRIs was modified and testing is scheduled for 1991. The SNRIs are to be used for the verification of inventory changes at such plants and will necessitate declarations of nuclear transfers by the operators in advance of such inspections.

System studies (cont.)

Agency policy on the use of C/S was revised and extended to permit the reduction of remeasurement requirements on all types of nuclear material to which dual C/S systems are successfully applied.

Instrument development

New non-destructive assay methods for measurement of total uranium and elemental ^{235}U quantities or concentrations in different materials, including difficult to analyse heterogeneous scrap, were developed and successfully applied.

A plutonium isotopic measurement technique based on state of the art hardware and software was developed, tested and evaluated. The technique will be introduced into routine use in 1991.

With the help of Member State support programmes, the preparation of standard measurement procedures reached an advanced stage, with six procedures approved in 1990 and nine more in the final stage of preparation. In addition, cadmium telluride gamma detectors that can be used in previously inaccessible locations were developed.

Under the programme for replacement of photographic optical surveillance units, the development of the compact surveillance and monitoring system (COSMOS) continued. Completion of development work and the production of standard units are expected in 1991.

By combining several development activities (tamper resistant television signal transmission link and intermediate signal storage) a new multi-camera video surveillance system (MOS) was developed. Extensive reliability testing is in progress.

A spent fuel attribute tester which does not require movement of the spent fuel reached an advanced stage of development. It is expected to be in routine use in 1991.

The development of a CANDU basket verifier specific to one facility was completed and the equipment commissioned and authorized for routine inspection use.

Neutron coincidence counting electronics and software to permit verification measurement of fuel elements in a scanning mode were developed and successfully tested at a fast reactor facility.

A gamma spectrometry based method for quantitative verification of spent LWR fuel was developed and commissioned for routine inspection use.

The median times required to complete verification by off-site destructive analysis (DA) were 49 days for uranium, 48 days for plutonium and 70 days for spent fuel samples.

Technical support for safeguards activities

	1988	1989	1990
Twin photo units in use	268	278	261
Photo cameras repaired and tested	301	288	227
Twin photo unit failures related to equipment	0.8%	0.5%	0.8%
Surveillance films developed at Headquarters	1658	1860	1907
Seals issued	15 900	14 618	15 300
Seals verified	15 508	13 543	14 851
Shipments of equipment and supplies	264	354	320
Hand carried equipment and supplies	374	412	425
Shipments of nuclear material and chemicals	113	124	141
Procurement actions	892	1240	1337
Samples analysed by SAL and NWAL	1173	1199	1512
MIVS systems installed in facilities	0	8	43

Instrument, equipment and analytical services

The Safeguards Analytical Laboratory (SAL) and the Network of Analytical Laboratories (NWAL) performed 3900 measurements for calibration and quality control of NDA techniques, for certification of secondary reference samples, for maintenance and improvement of off-site DA and for testing procedures for on-site DA.

Work continued on the development of methods and procedures for on-site independent DA verification measurements, especially in the following areas:

- The thermal quadrupole mass spectrometric method for plutonium and americium isotopic analysis based on the use of the total evaporation technique.
- The rapid and automatic preparation of bead samples of nuclear fuels in oxide form for on-site X ray analysis.
- The hybrid K edge densitometer technique for the analysis of uranium and plutonium in product material and spent fuel samples. This technique has been tested for possible use as a backup technique for off-site DA and also for technical support and the training of inspectors.
- The field testing of a robotic system for chemical treatment of diluted spent fuel solutions. This work was pursued with the assistance of two Member State support programmes.

Standardization and quality assurance activities

A total of 2286 inspection reports (2289 in 1989) and 2485 inspection statements (2494 in 1989) were reviewed and computerized quality control checks applied. Reports on the quality and timeliness of inspection documentation packages were made routinely.

The average time required between an inspection and the dispatch of the results to the State in which the inspection was performed was 53 days (50 in 1989 and 64 in 1988).

Statistical analysis

Major revisions in inspection sample size and material balance evaluation methodologies, along with supporting documentation and training material, were prepared for implementation in 1991. Both revisions will result in more effective utilization of the Agency's constantly improving non-destructive measurement capabilities. Specific verification performance histories have been established for each combination of facility, material type and measurement method.

During 1990, 390 routine data evaluation reports were prepared. The total comprises material balance evaluations (118), operator-inspector pair evaluations (195) and verification performance history analyses (77).

Training

Two introductory courses were conducted for new inspectors. Twenty other training courses for Professional and General Service staff as well as individual training were organized at Headquarters and in the field. Substantial support in the organization and conduct of training courses continued to be provided by Member States.

Data processing

The computerized accounting data system for INFCIRC/66/Rev.2-type agreements was further augmented by additional applications software. The transit accounting process was enhanced by the computerization of data which is received by the Agency pursuant to paragraphs 34(a) and 34(b) of INFCIRC/153.

A version of the IFSS which incorporates all the functional requirements originally envisaged was completed and subsequently authorized for routine use.

In preparation for the introduction of the safeguards criteria to be used for implementation and evaluation in the period 1991–1995, work was started on rewriting computer programs and documenting the computerized inspection report (CIR) system.

With the assistance of a Member State support programme, a pilot office application project was completed to provide a basis for planning the introduction of local area network (LAN) technology.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Course for junior professionals from developing countries	Headquarters, Austria, Germany, Czechoslovakia	4	1 year
Regional course on implementation of State Systems for Accounting and Control of Nuclear Materials	Argentina	22	2.5 weeks
Basic course on implementation of State Systems for Accounting and Control of Nuclear Materials	USSR	26	2 weeks

Direction and support

Administration

Regular Budget

On the basis of an exchange rate of 12.70 Austrian Schillings to one United States dollar, the General Conference appropriated an amount of $162 832 000 for the Regular Budget. This amount had to be adjusted in accordance with the adjustment formula presented in the attachment to resolution GC(XXXIII)/RES/516 in order to take into account the exchange rate actually experienced during the year — 11.43 Austrian schillings to one United States dollar.

The Regular Budget for 1990, at an exchange rate of 11.43 Austrian Schillings to one United States dollars amounted to $178 653 000, of which $170 135 000 was to be financed from contributions by Member States on the basis of the 1990 scale of assessment, $4 933 000 from income from work for others and $3 584 000 from other miscellaneous income.

Expenditures

The actual expenditures in 1990 amounted to $176 500 274, resulting in an unencumbered balance of $2 152 726.

Voluntary contributions

The target for voluntary contributions to the Technical Assistance and Co-operation Fund in 1990 was established at $45.5 million. At the end of the year, $38 797 255 had been pledged by Member States in support of the technical assistance programme.

Extrabudgetary contributions

A total of $22 113 296 was offered in extrabudgetary contributions by Member States, the United Nations and other international organizations during 1990. Of this amount, $6 920 018 was for technical assistance projects, $5 728 727 was in support of safeguards, $2 098 559 was for activities of the Third World Academy of Sciences (TWAS), $1 946 861 for projects in the field of food and agriculture, $1 304 203 in support of Funds in Trust and $1 073 937 for Regional Co-operative Agreements (RCA). The remaining $3 040 991 was in support of various other projects implemented by the Agency.

In addition, extrabudgetary resources amounting to $17 887 536 were donated for the International Centre for Theoretical Physics and $2 806 140 for the International Laboratory of Marine Radioactivity.

New payroll system

In 1990, a consultancy firm was engaged to develop a new integrated payroll system to replace the existing one, which no longer meets the Agency's requirements. The first phase of the firm's work (definition of the Agency's requirements) and part of the second phase (conceptional design) were financed through an extrabudgetary contribution from the Government of Germany, while the remainder of the second phase was covered from the Regular Budget.

New External Auditor

The General Conference, at its thirty-third session in 1989, appointed the Auditor General of Canada to serve as the External Auditor for the audit of the Agency's Accounts for the years 1990 and 1991. The newly appointed External Auditor carried out the interim audit of the 1990 Accounts in autumn 1990.

1991 and 1992 Programme Budgets

The Programme Budget document for 1991 and 1992 was presented to the General Conference in a new, detailed project oriented format.

Personnel

At the end of 1990, the number of members of the Secretariat was 2175 — 832 in the Professional and higher categories, 1202 in the General Service category and 141 in the Maintenance and Operatives Service category. These figures represent: members of the Secretariat occupying manning table posts (1644) or charged to manning table posts (94) or to the temporary assistance fund (119); officials serving on a reimbursement basis (244) or on secondment (2); and Commissary staff (72).

Among the 622 staff members in posts subject to geographical distribution, 75 nationalities were represented. The percentage of female staff in posts subject to geographical distribution was, on 31 December 1990, 12.21%.

Computerization of the personnel/payroll system

The first phase of the development of the computerized personnel/payroll system was concluded. The work was carried out by a cost free consultancy firm, financed by the Government of Germany.

Because of the zero growth environment, the Agency is increasingly dependent on extrabudgetary resources, cost free experts and temporary assistance staff. The policies and procedures for the employment of such personnel were revised and standardized.

VIC Medical Service

A review of the VIC Medical Service was carried out by a consultancy firm, resulting in the signing of a Memorandum of Understanding with the Doctor's Board of Vienna (Ärztekammer) to obtain better medical assistance for staff and their families, and the use of outside contractors to the extent possible to reduce costs and increase efficiency.

LAN

A local area network (LAN) was installed in the Division of Personnel and is now functioning, resulting in reduced dependence on the mainframe computer.

Organizational structure

The organizational chart showing the structure of the Secretariat can be found at the end of the Annual Report.

Conventions relating to nuclear accidents

The Convention on Early Notification of a Nuclear Accident (reproduced in document INFCIRC/335), which entered into force on 27 October 1986, was ratified by five States and acceded to by three States and two international organizations during 1990. By the end of the year there were 54 Parties.

The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (reproduced in document INFCIRC/336), which entered into force on 26 February 1987, was ratified or approved by five States and acceded to by four States and two international organizations during 1990. By the end of the year there were 50 Parties.

Physical Protection Convention

The status of the Convention on the Physical Protection of Nuclear Material (reproduced in document INFCIRC/274/Rev. 1.), which entered into force on 8 February 1987, remained unchanged: 28 States were Party to it.

Agreement on the Privileges and Immunities of the IAEA

By the end of 1990, there were no additional acceptances of the Agreement on Privileges and Immunities (reproduced in document INFCIRC/9/Rev. 1). The number of Member States who have accepted the Agreement is 61.

Position of Germany in relation to conventions and agreements

The German Democratic Republic and the Federal Republic of Germany have been Parties to the Notification and Assistance Conventions since 29 April 1987 and 14 September 1989, and to the Agreement on Privileges and Immunities since 30 October 1974 and 4 August 1960, respectively. The German Democratic Republic has also been a Party to the Physical Protection Convention since 8 February 1987. By a Note of 4 October 1990, the Federal Republic of Germany informed the Director General that following the accession by the German Democratic Republic to the Federal Republic of Germany with effect from 3 October 1990, agreements to which the Federal Republic of Germany is a Contracting Party shall, with the exception of certain treaties not relevant to the Agency, retain their validity and that the rights and obligations arising therefrom shall also relate to the territory of the former German Democratic Republic. By the same Note, the Director General was informed that the united Germany will determine its position with regard to the treaties of the German Democratic Republic following consultation with Parties to the treaties and will inform the Agency accordingly.

African Regional Co-operative Agreement

The African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Energy (AFRA) (reproduced in document INFCIRC/377) entered into force on 4 April 1990. By the end of the year, it had been accepted by 9 States.

Code of Practice on the International Transboundary Movement of Radioactive Waste

The Technical Working Group which was set up in 1989 in response to resolution GC(XXXII)/RES/490 of the General Conference, adopted in February 1990 a text of a Code of Practice on the International Transboundary Movement of Radioactive Waste (reproduced in document INFCIRC/386). The Code affirms the sovereign right of every State to prohibit the movement of radioactive waste into, from or through its territory. The Code requires that transboundary movements of radioactive waste should only take place in accordance with internationally accepted safety standards, with prior notification and consent of the sending, receiving and transit States and in accordance with their respective laws and regulations; the Code prescribes that all States involved should have the administrative and technical capacity as well as the regulatory structure required to manage and dispose of radioactive waste in a manner consistent with international safety standards.

The General Conference, at its thirty-fourth session, adopted the Code by resolution GC(XXXIV)/RES/530, requested the Director General, inter alia, to monitor its implementation by Member States and to report to the General Conference as appropriate, and decided to keep the matter under active review, including the desirability of concluding a legally binding instrument under the auspices of the Agency.

Liability for nuclear damage

The Vienna Convention on Civil Liability for Nuclear Damage, which entered into force on 12 November 1977, was acceded to by one State during 1990. By the end of the year, there were 14 Parties.

On 15 May 1990, the Director General, in his capacity as the depositary of the Vienna Convention, received the required number of requests for convening of a revision conference in accordance with Article XXVI(1) of that Convention.

Liability for nuclear damage (cont.)

The Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention on Third Party Liability in the Field of Nuclear Energy, which was opened for signature on 21 September 1988, was approved by one State and acceded to by one State during 1990. By the end of the year five States had ratified, approved or acceded to it. The Protocol will enter into force three months after the date of deposit of instruments of ratification, acceptance, approval or accession by at least five States Party to the Vienna Convention and five States Party to the Paris Convention.

At its session in February 1990, the Board established a Standing Committee on Liability for Nuclear Damage. The tasks of the Committee are to: consider civil and State liability for nuclear damage, and the relationship between them; keep under review problems relating to the Vienna Convention; and make the necessary preparations and arrangements for a revision conference for the Vienna Convention. The new Standing Committee replaces both the Working Group established in 1989 and the Standing Committee on Civil Liability.

At the two sessions of the Committee, there was a consensus on the need to revise the existing civil liability conventions. Specific draft amendments to the Vienna Convention relating, inter alia, to the concept of nuclear damage, geographical scope, application to military installations, financial limit of liability and time limits for submission of claims, have been agreed upon as a basis for future consideration. Consideration is also being given to the establishment of a system of supplementary funding for compensation for nuclear damage in addition to the liability of the operator as well as to the establishment of an international claims settlement procedure. When preparatory work for the revision of the Vienna Convention has been completed, the Standing Committee will advise the Director General on an appropriate date for convening a revision conference, pursuant to Article XXVI of the Convention (tentatively envisaged for the end of 1991 or 1992). The Standing Committee is also considering issues of State liability.

The report of the first session of the Standing Committee was considered by the Board of Governors in September. The General Conference, acting upon the report by the Board, reiterated the priority it attached to the question of liability for nuclear damage and requested the Board to submit a progress report to its thirty-fifth session (GC(XXXIV)/RES/529).

Publications

Series and No.	Title
Legal Series No. 15	Bilateral, regional and multilateral agreements relating to co-operation in the field of nuclear safety

Technical co-operation servicing and co-ordination

General issues during 1990

The first biennial technical co-operation programme was concluded in 1990. While the advantages and/or disadvantages of a two year cycle will be the subject of a special evaluation during 1991, the experience so far has been positive for the Secretariat. The advantages of the two year cycle — in combination with various steps taken to increase efficiency, such as the reorganization of the Department of Technical Co-operation and the expanding use of computers — resulted in a significant increase in programme delivery (from 56.5% to 67.0%) for the programme as a whole.

Further software developments were undertaken to enhance productivity in the Department of Technical Co-operation. The Department's local area network (LAN) was expanded by approximately 20% and some 100 staff members now have direct access to common databases and applications.

The African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA) entered into force in April 1990, with ten African Member States acceding to it during the year. Several regional activities proposed by an AFRA technical working group were included in the 1991-1992 programme.

The Agency continued to participate in United Nations system discussions relating to technical co-operation issues. Every effort is being made to strengthen liaison with UNDP. Attempts to stem the decline in the UNDP portion of the programme can, however, only be successful if central planning authorities in recipient Member States accord sufficient priority to projects in the nuclear field for them to be included in the UNDP country programmes.

The percentage of women benefiting from the Agency's technical co-operation activities, in particular with respect to training, has steadily increased, with women representing 22.4% of all fellows, 18.5% of all visiting scientists, 19.2% of all training course participants and 12.5% of all project counterparts. The corresponding figures for 1989 were 22%, 17.7%, 16.0% and 10.5% respectively.

Programme implementation and trends

A total of 1135 projects were operational during 1990. These ranged in size from one month of expert services valued at $8400 to multi year projects with 1990 budgets of around $1 million.

The provision of technical assistance in 1990 involved arranging for 2220 expert assignments, processing 3152 purchase orders for equipment and supplies, devising training programmes for 1057 fellows and visiting scientists, and organizing 108 regional and interregional training courses for 1358 participants. In addition to these courses, 86 of which took place in developing countries, 89 national group training events were carried out.

The technical divisions of the Secretariat continued their active involvement in the technical co-operation programme. A total of 159 technical officers provided support to the programme, carrying out 512 assignments as experts or as training course lecturers for a total of 153 months. In addition to their technical supervision of ongoing projects, they evaluated 1161 fellowship applications.

Technical co-operation programme delivery

	1986	1987	1988	1989	1990
Number of expert/lecturer assignments	1930	1808	2023	2144	2220
Number of expert/lecturer months served	1516	1356	1239	1246	1211
Number of expert/lecturer assignments undertaken by Agency staff	449	407	430	444	512
Number of purchase orders processed	3738	3701	3386	3894	3763
Number of fellows in the field	734	870	682	732	814
Number of visiting scientists	203	160	156	192	243
Number of participants in training courses	972	945	1109	1265	1358

Resources and implementation

New resources available for technical co-operation decreased by 11.1% ($5.5 million) over the previous year to $44.6 million. However, this is due solely to a bookkeeping loss caused by the devaluation of a major non-convertible currency. Without this, resources would have shown an increase of 5.9% to $53.1 million.

For the first time since 1983, the percentage of the target for the Technical Assistance and Co-operation Fund (TACF) which was met through pledges did not decline: 85.3% of the $45.5 million target was pledged in 1990 as compared with 85.1% of the $42.2 million target in 1989. Normally, miscellaneous income received in addition to the pledges exceeds exchange losses, so that a higher percentage of a given year's target is obtained than that which is actually pledged. Owing to the exchange losses mentioned above, the reverse was true in 1990, so that overall income to the TACF represented 76.1% of the target.

The TACF accounted for 77.8% of total available resources, extrabudgetary funds for 16.8%, UNDP for 6.4% and assistance in kind for 5%.

The value of the programme planned for implementation (total adjusted programme for 1990) stood at $62.6 million. Obligations were entered into for goods and services valued at $42.4 million (against $37.7 million in 1989), yielding an overall implementation rate for the programme of 67.8% as compared with 56.5% in 1989. The increase in the implementation rate was particularly pronounced in that part of the programme financed from the TACF, where the rate went up from 58% in 1989 to 71.3% in 1990.

Implementation by resource category

Resource category	Adjusted programme ($)	Share of total programme (%)	Net new obligations ($)	Implementation rate (%)
TACF	46 880 397	74.9	33 422 585	71.3
Extrabudgetary	11 687 023	18.7	5 888 500	50.4
UNDP	3 223 083	5.2	2 855 764	88.6
Funds in trust	767 633	1.2	273 457	35.6
Total	62 558 136	100.0	42 440 306	67.8

Distribution of assistance

Of the total value of the adjusted programme in 1990, equipment accounted for 37.7%, followed by training at 30.9% and experts at 28%. Delivery in each of these components exceeded the implementation rates of prior years.

Implementation by assistance component

Component	Adjusted programme ($)	Share of total programme (%)	Net new obligations ($)	Implementation rate (%)
Experts	17 532 491	28.0	9 994 971	57.0
Equipment	23 564 330	37.7	15 647 674	66.4
Fellowships	9 704 290	15.5	6 785 108	69.9
Training courses	9 626 232	15.4	8 340 599	86.6
Subcontracts	1 527 954	2.5	1 108 858	72.6
Miscellaneous	602 839	0.9	563 096	93.4
Total	62 558 136	100.0	42 440 306	67.8

In terms of the Agency's budgetary areas of activity, 24.9% of all disbursements for technical co-operation were made for physical and chemical sciences, followed by 19.7% for agriculture and 14.3% for industry and earth sciences.

In Africa, by far the largest share of disbursements (32.9%) went for food and agriculture, followed by physical and chemical sciences (19.5%) and radiation protection (13.3%). In Asia and the Pacific, disbursements for physical and chemical sciences amounted to 21.8%, followed by food and agriculture (20.3%), human health (14.8%) and industry and earth sciences (14.7%). In Europe, physical and chemical sciences dominated, with 41.4% of all disbursements, followed by industry and earth sciences (17%) and safety of nuclear installations (9.5%). In Latin America, a fairly even distribution of disbursements was noted in three major fields: physical and chemical sciences (23.7%), food and agriculture (21.2%) and industry and earth sciences (20.2%). In the Middle East, the largest share of disbursements (43.2%) was for radiation protection.

The overall distribution of the assistance provided to the various regions followed the pattern that has prevailed over the past five years.

Assistance provided to various regions

Region	Overall share (%)						
	1985	1986	1987	1988	1989	Average 1985–1989	1990
Africa	20.8	19.9	18.4	20.1	20.5	19.9	18.2
Asia and Pacific	28.3	26.7	30.0	29.0	29.6	28.7	31.9
Europe	13.1	13.6	18.9	13.8	13.4	14.5	16.3
Latin America	22.5	22.4	20.3	23.0	25.8	22.8	22.1
Middle East	1.5	3.1	2.1	3.0	2.1	2.4	2.4
Interregional	13.8	14.3	10.3	11.1	8.6	11.6	9.1

Evaluation

Evaluation activities continue to provide indispensable feedback on the Agency's technical co-operation activities. Two sectoral and several other major evaluations during 1990 showed that the programme is making significant contributions to the attainment of development objectives in Member States. The shortcomings identified provide valuable guidance for future programming.

Specialized service activities

Public information

The scope of the public information programme was significantly enlarged as a result of a first extrabudgetary contribution from Japan, together with the provision by the USA of a professional staff member on a cost free basis, permitting implementation of a number of special projects. Among these were two regional nuclear energy information seminars for the media held in Australia and Japan. A new series of fact sheets, covering key topics of public concern, was prepared for use at these events and for wider dissemination. The subjects included safeguards and the peaceful uses of nuclear energy, nuclear techniques, radiation in everyday life and waste management.

Video production was also expanded, with films being made on nuclear energy and the environment and the international assessment of the consequences of the Chernobyl accident.

Additionally, the first Public Information Forum was staged in Vienna at the time of the General Conference session. This initiative brought together over 80 media representatives, government information officials and industry specialists from 35 Member States for a broad review of nuclear information problems and strategies.

A display on the Agency's work was arranged during the Fourth NPT Review Conference in Geneva.

Periodicals and brochures

In addition to the regular periodicals (IAEA Bulletin, News Features and Newsbriefs), the second edition of 'Highlights' — the popularized version of the Annual Report — was produced, as were a number of brochures. Support was given to the launching of several Agency initiatives, including the International Nuclear Event Scale (INES). In co-operation with other United Nations bodies in Vienna, an environmental folder was produced, incorporating a section on nuclear energy and the environment.

INIS membership

Sudan joined the International Nuclear Information System (INIS) in November. The reunification of Germany left the number of Member States at 79; international member organizations remained at 15.

Liaison officers meeting and international symposium

The 18th Consultative Meeting of INIS Liaison Officers was held in Obninsk, USSR. It was followed by a symposium in Leningrad on the future of scientific, technological and industrial information services, which was co-sponsored by the IAEA (as lead Agency), FAO, UNESCO and UNIDO. The symposium provided an opportunity for participants to become aware of recent advances in technologies and methodologies for information transfer and in information policies and management.

INIS database

In 1990, 95 604 records were added, bringing the INIS database to 1 447 960 records. Over 99% of the input was received in machine readable form. The highest percentage of input is still contributed by journals, followed by reports and books.

On-line access to the INIS database by users in Member States dropped slightly in 1990 to around 700 hours. Magnetic tapes and cartridges containing INIS files were sent to 35 members.

Microfiche

The INIS Clearinghouse distributed about 510 000 microfiches, representing over 25 million printed pages. By the end of the year the collection of documents approached 242 000 (around 320 000 microfiches).

Computer output on microfiche

Nearly 11 million printed pages were distributed in computer aided microfiche (COM) format in 1990 (over 25 million since the beginning of the operation).

Subject scope

Following decisions of the INIS Advisory Committee on changes in INIS subject scope, all INIS Members were invited to provide suggestions for improvements. Revised material is being prepared for a Technical Committee, which will meet early in 1991.

INIS–ETDE co-operation

On the basis of an agreement between the Agency and the IEA, specialists in INIS and the Energy Technology Data Exchange (ETDE) have begun working to improve compatibility between the INIS and ETDE systems.

Indexing study

In co-operation with the operating agent of ETDE, an indexing study was carried out with the assistance of a contracted expert. The study surveyed current indexing and subject control practices of large database producers worldwide and investigated new approaches and methods for exercising subject control. A meeting of representatives of 15 large database producers was organized by INIS and ETDE at the national INIS centre of the USA. INIS will incorporate ideas evolving from the study in its future activities related to the subject and its control of documents entering the database.

Training courses and seminars held

Course name	Location	No. of participants	Duration
INIS training seminar	Headquarters	39	1 week

Shared support services

Library collection and services

The VIC Library added the 100 000th record to the LION database, its on-line catalogue of holdings. The number of items loaned to VIC users grew by 16%. The number of Current Awareness Bulletins (CABs) compiled and distributed to staff increased by 23%, from 16 200 to 19 926. The CAB service is currently available in 14 subject series and provides users with a copy of the tables of contents from approximately 500 of the 4000 journal titles kept in the Library.

A selection of discarded abstracting journals was donated to university libraries in five developing countries through the Third World Academy of Sciences. Loans of films were made to nuclear energy commissions, schools, universities and media organizations in 32 Member States.

Technology in the VIC Library

The on-line user access catalogue, VICLINE, is now fully operational. VICLINE will be one of the databases available in the pilot project for the use of mainframe computer services by Vienna based missions.

In the continuing effort to explore ways of using new technology to improve ease of data access, CD-ROM optical disk drives have been installed in both the Technical Services office and the Reference Room of the Library.

The Library has expanded its use of the United Nations Bibliographic Information System (UNBIS) databases, which are available on-line from New York and directly searchable via the central Agency mainframe computer telecommunication lines to Geneva and New York. UNBIS also now functions as the VIC Library's index to its document holdings.

The number of PCs connected to the Library's LAN was increased to 12. The major application of the LAN will be to improve control over the approximately 42 794 journal issues received annually by the Library.

Computer applications development and support

The on-line system supporting various administrative aspects of official travel was extended to the Departments of Administration, Nuclear Energy and Safety and Research and Isotopes. The programming required for the printing of INIS Atomindex on a laser printer was completed and implemented. An improved version of the research contracts system was implemented — the main enhancements including automatic printing of contracts and obligation data. In the area of Technical Co-operation, a number of program innovations, improvements and extensions were introduced (dealing in particular with the link to FICS and the expert database). Data from Canada, the USA and EEC countries were uploaded to PRIS. Completion of a dynamic simulator for nuclear power plants and an updating of the hydrology data file for statistical evaluation were accomplished.

End-user support

WordPerfect version 5.1 was adopted as the PC word processing standard. An organizational framework and structure was established for the support of LANs within the Secretariat. Briefings on LAN planning were held with users to inform them of hardware and software requirements, costs and technical support. A user friendly LAN interface was developed and a LAN implementation guide written.

Utilization of Agency mainframe computers (prime CPU hours)

	1985	1986	1987	1988	1989	1990
Safeguards	1608	2673	2679	3035	3504	3652
Shared	3029	3428	4494	6205	7470	7258

Utilization of mainframes and decentralization

Utilization by the Department of Safeguards of its dedicated central computer during prime operating hours increased by 7%. Utilization of the shared central computer remained in total equal to the utilization in 1989. This apparent stagnation was the result of continuing growth in computer utilization by the Agency and the movement by UNIDO of its applications (about 20% of the workload) to its own mainframe computer in July. It is projected that the extra capacity thus made available will be consumed by existing Agency applications by the end of 1991. UNIDO was assisted in moving all its applications, and communications links between the Agency's common computer and UNIDO's computer were established.

Replacement of mainframes

An Open Ended Experts Group meeting was convened by the Board of Governors in October to consider the Secretariat's proposal to upgrade the Agency's computer services for 1991–1996. In summary, the Group recommended that the Board of Governors approve an amount of up to $5.5 million to be expended on: upgrading the central computing facility with sufficient capacity and functionality for the period until 1996; and implementing the hardware, software and contracts required to establish the technical infrastructure to facilitate an accelerated decentralization of applications.

External network

Enhancements were made to the external network: electronic mail facilities to New York were extended; a dial-up line for access to Bankers Trust and Chase Manhattan Bank via Radio Austria was completed; a pilot project was started to allow Permanent Missions in Vienna to access the Agency's computer for electronic mail purposes; and a data communications facility was installed between Agency Headquarters and Seibersdorf. Extensive use of the international electronic mail system EARN/BITNET was made for exchange of messages between the Agency and affiliated institutions in Member States.

Internal network

Development of LANs and their integration into the overall internal network continued with the implementation of vertical (backbone) optical fibre cabling in the Agency buildings. Other accomplishments were the standardization and implementation of LAN to mainframe connectivity; the expansion of LAN capacity and the installation of a floor LAN in the Nuclear Data Section; and the installation of 172 new end-user devices (mostly PCs). A further five floors were wired with the standard cabling system.

Publishing

The preparation, publishing, distribution and sale of books, journals and reports continued to be one of the major means by which the results of Agency work are made known and disseminated in Member Sates. In line with the pre-eminence of the Agency in the international nuclear field, the quality of these publications remained of primary importance. In 1990, around 62 000 copies of publications were sold and some 95 000 copies distributed free of charge. The total income from sales of all types of publication was $1.40 million.

Growing use was made, where cost effectiveness had been demonstrated, of computer aided means of publishing. Closer liaison with originating Divisions was organized with the aim of providing advance advice on publications related matters and of involving authors and consultants more in the book promotion and distribution process.

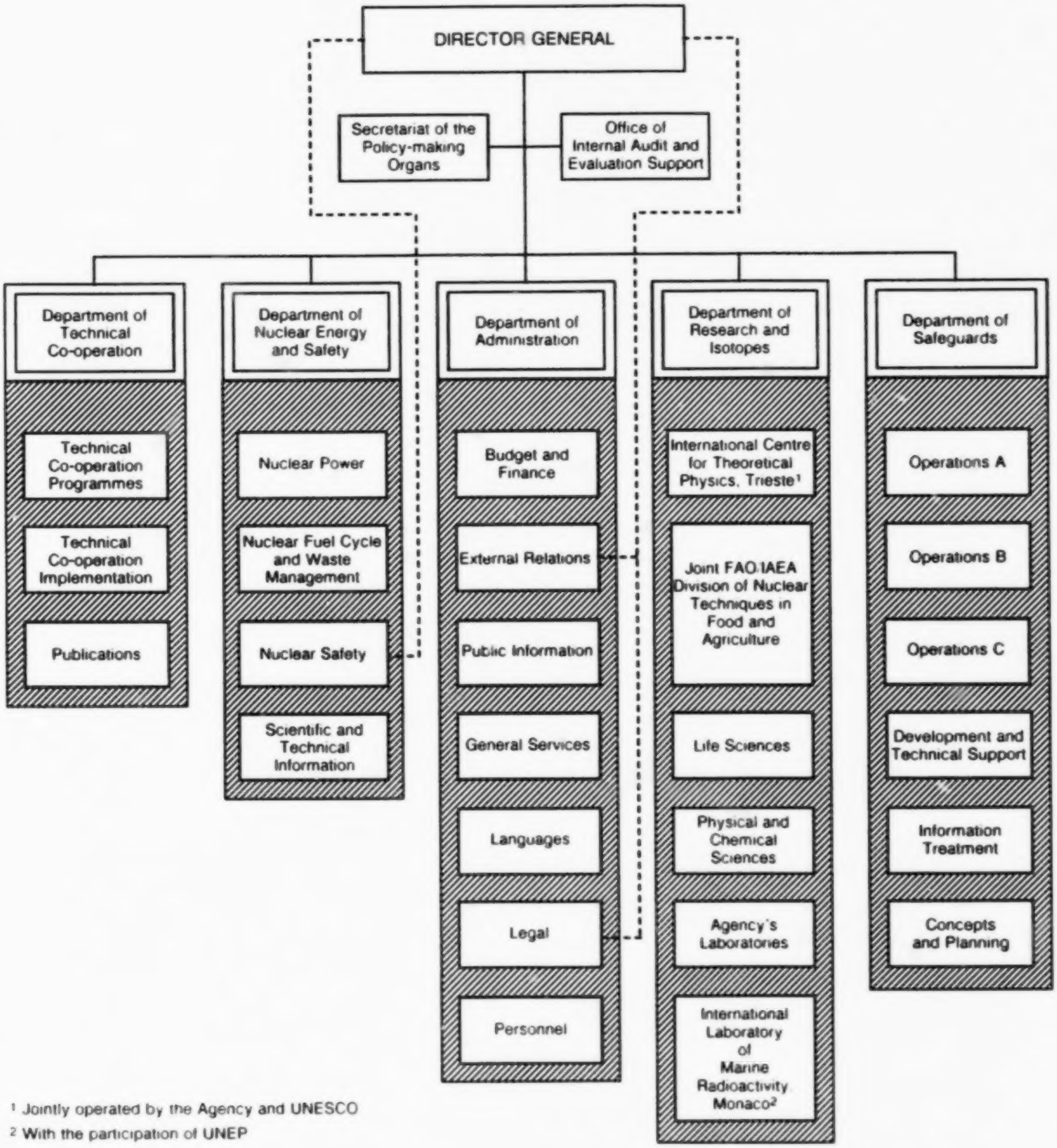
In 1990, some 220 new titles were published. In addition to the books tabulated elsewhere in this report, 7 books were published in Chinese, 5 in French, 13 in Russian and 2 in Spanish.

Printing

The Common Printing Service continued to provide document and publications printing services for the Agency and also for UNIDO and the United Nations bodies based at the VIC. In 1990, the income from work for other organizations was around $1.77 million. The output of the Common Printing Service was 185 million pages impressions compared with 204 million in 1989.

ORGANIZATIONAL CHART

(as of 31 December 1990)


DIRECTOR GENERAL
Secretariat of the Policy-making Organs
Office of Internal Audit and Evaluation Support
Department of Technical Co-operation
Technical Co-operation Programmes
Technical Co-operation Implementation
Publications
Department of Nuclear Energy and Safety
Nuclear Power
Nuclear Fuel Cycle and Waste Management
Nuclear Safety
Scientific and Technical Information
Department of Administration
Budget and Finance
External Relations
Public Information
General Services
Languages
Legal
Personnel
Department of Research and Isotopes
International Centre for Theoretical Physics, Trieste[1]
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
Life Sciences
Physical and Chemical Sciences
Agency's Laboratories
International Laboratory of Marine Radioactivity Monaco[2]
Department of Safeguards
Operations A
Operations B
Operations C
Development and Technical Support
Information Treatment
Concepts and Planning

[1] Jointly operated by the Agency and UNESCO

[2] With the participation of UNEP